COTTON

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COTTON FLOWER AND BOLL

COTTON

FROM THE RAW MATERIAL TO THE FINISHED PRODUCT

BY

R. J. PEAKE

REVISED AND ENLARGED
BY

P. CURTIS, F.T.I.

MEMBER OF LANCASHIRE SECTION COMMITTEE OF THE TEXTILE INSTITUTE
AUTHOR OF "GLOSSARY OF TEXTILE TERMS," "THE TESTING OF YARNS AND FABRICS," AND "MANCHESTER PIECE GOODS" (PITMAN'S TEXTILE EDUCATOR)

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PREFACE

TO THE FOURTH EDITION

THE rapidity with which the three previous editions of this book have been absorbed by students and the public generally is fairly conclusive proof that it supplies a demand. This is quite understandable, since every human being finds some use for cotton for clothing, household purposes, or for decoration; in fact, there is hardly a living person who can say he has no use for cotton.

Every chapter in this new edition has been revised and new matter added in order to make the work more serviceable to textile students, employees in the drapery trade, and all who are interested in the development of the cotton fibre from the seed to the finished fabric. Non-technical language has been used as far as possible in order to enable the general public to follow each process with interest.

As mentioned in the previous edition, Chapter II is the work of Mr. John A. Todd, Principal of the City School of Commerce, Liverpool, and author of *The World's Cotton Crops*, upon which book certain parts of this chapter are based, by the kind permission of the publishers, Messrs. A. and C. Black, Ltd.

New inventions, such as the Shirley analyser, and those for cross-winding and high drafting in the spinning section, automatic looms and weft winding, etc., are considered. The increasing popularity of fancy yarns, especially those produced by the doubler, has demanded a notice in Chapter III.

Such organizations as the Manchester Chamber of Commerce, the Joint Committee of Cotton Trade Organizations, the British Cotton Industry Research Association, the Textile Institute, and the International Federation of Cotton Spinners' and Manufacturers' Associations and their very important work have been briefly touched upon,

as in a work of this kind it is impossible to describe their activities fully.

The very urgent subject of Technical Education is discussed in Chapter VIII, where the views of W. Munn Rankin, M.Sc., are given; these are of such outstanding value that they should be studied by all educational bodies concerned with the textile trades.

Many more additional illustrations are included with a view to making the text more readable, and many thanks are due to the manufacturers who have allowed the illustration of their machines and supplied the necessary blocks.

HARRY P. CURTIS.

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CHAPTER I

FOUNDATION OF THE ENGLISH COTTON TRADE

THE importance of the Cotton Trade of the United Kingdom is seen in the amount of capital invested in it, the number of people employed in the sheds, factories, and works connected with the production and finishing of cloth step by step from the raw material, the thousands engaged in the distribution of the finished goods in all the markets of the world, and the variety of useful and artistic productions which come from the looms. The arts of spinning and weaving are among the oldest in the world. Long before the days of European history people were vestured in woven cloths. Four thousand years before Christ linen cloths were in common use in Egypt. Joseph arrayed himself in vestures of fine linen, and Joseph's coat of many colours shows that great men's children were clothed in coloured garments. When the Tabernacle was constructed in the wilderness, two centuries later, by Moses, "The women that were wise-hearted did spin with their hands, and brought that which they had spun, both of blue and of purple, and of scarlet, and of fine linen."

The Hebrews used three words for linen, viz. *bad*, *shesh*, and *butz*. It is considered that *bad* only referred to linen from which the priests' garments were made, that *shesh* denoted cotton of which the curtains of the Tabernacle consisted, and *butz* indicated the silky fibre found on the shell-fish called "pinna."

It is believed that cotton manufacture was first developed in India and thence spread to Persia, Egypt, and later into Europe. Throughout India the arts of spinning

and weaving cotton fabrics have been practised from remote antiquity. In Bengal were produced, over 1,600 years ago, cotton fabrics that were famed all over the world for their fineness. The muslins woven in Dacca were so fine in texture that they were thought to be the work of fairies or insects. The yarn was spun by hand from locally grown cotton and woven into cloth on native hand-looms. It is a remarkable fact that no machine-made muslin has ever equalled the Dacca muslin for fineness.

Almost four centuries before the Christian era we are told that the ordinary wear of the Indians was cotton cloths. Strabo speaks of their flowered cottons or chintzes, and of the lustre and vivid quality of the dyes with which they figured their cloths. He also mentions the capacious "sagum" as "a garment open in the middle, which descended nearly to the knees."

All over the East cloth fabrication was among the oldest of all arts, and in America it is said that the arts of spinning and weaving were carried on by the earliest settlers, who found the cotton and indigo plants indigenous.

The first record of cotton cloths among the argosies of the East is in *The Circumnavigation of the Erythræan Sea*, in which Arrian, an Egyptian Greek, refers to the Arab traders bringing Indian cottons to Aduli, a port on the Red Sea. Ports beyond the Red Sea had an established trade in calicoes, muslins, and other cottons, both plain and bearing floral ornamentation.

The ancient Britons and Gauls excelled in the art of dyeing cloth. Pliny names many herbs used for this purpose, and states that they obtained purple, scarlet, and other colours from them. The favourite colour of the early Britons appears to have been blue, produced from the woad. Their dress consisted of a close coat or cloak shaped like a tunic, and is described as checkered with various colours. It was open in front and had long sleeves. Below this they wore loose, trouser-like garments called

by the Irish *brigés*, and by the Romans *brayes* and *braccae*; hence the modern term "breeches."

It does seem remarkable, as Mr. Baines points out, that a branch of industry so apt to propagate itself should have lingered thirteen hundred years on the coast of the Mediterranean before it crossed that sea to Greece or Italy, for the costly silks of China had long before been quite eagerly sought by the ladies of Rome and Constantinople. From the East the textile arts gradually spread to Europe. In Greece, in the tenth century, silks, woollens, and linens were made, and silks were made on a large scale in Southern Italy in the twelfth, thirteenth, and fourteenth centuries. The Flemings, under the patronage of Henry I, established a colony in Pembrokeshire, and there started the manufacture of woollen cloth. In the year 1153 a charter was granted to the Priory of St. Bartholomew to hold an annual fair which developed into the Great Cloth Fair.

There were big woollen manufactories at the same period in Flanders, Tuscany, etc., but it was left to Mohammedan Spain to manufacture cloths from cotton as early as the tenth century, as well as to copy the artistic fabrications of the seats of Mohammedan luxury in the East. Venice exported a variety of cottons in 1560, and Milan sent out fustians and dimities of many sorts. The first record of cotton in English trade is contained in a work written towards the close of the fifteenth century by Hakluyt, who says that the ships of Genoa brought from England, among other commodities, cotton. In 1601 it is recorded that cotton was brought to England by the Antwerpians from Sicily, the Levant, and Lisbon. When the refugees from the Low Countries in the second half of the sixteenth century, fleeing from persecution, settled in England, they are said to have pursued the manufacturing arts they had practised at home. There is, however, no positive proof that the Flemish weavers, who settled in the neighbourhood of Manchester, did actually begin our English cotton manufacture. It is practically certain that

many of the woven goods called "cottons" in 1552 were really woollen stuffs. (Actually, prior to 1641, the fabrics then known as "Manchester cottons" were still made of wool.) In 1641 Lewis Roberts published *The Treasure of Traffic*, in which he says (speaking of Manchester): "They buy *cotton wool* in London, that comes first from Cyprus and Smyrna, and at home worke the same and perfect it into *fustians*, *vermillions*, *dimities*, and other stuffes, and then return it to London, where the same is sold, and not seldom sent into forrain parts, who have means, at far easier termes, to provide themselves of the said raw materials."

Thus, it appears that, in the year 1641, cotton manufacture was established in Manchester, and both the home trade and distant markets were supplied with several kinds of cotton goods.

In 1662 Dr. Fuller says that the inhabitants of Manchester "buying the *cotton wool* or *yarne* coming from beyond the sea, make it here into fustians, to the good employment of the poor, and great improvement of the rich therein, serving mean people for their outsides, and their betters for the lining of their garments. Bolton is the staple place for this commodity, being brought thither from all parts of the country. As for Manchester, the *cottons* thereof carry away the credit in our nation, and so they did a hundred and fifty years ago. For, when learned Leland, on the cost of King Henry the Eighth, with his guide, travailed Lancashire, he called Manchester the fairest and quickest town in the country."

For over a hundred years after Roberts wrote his book on Traffic in 1641, India kept far in front of Europe in the manufacture of cotton goods. The far Eastern trading companies gained great wealth by this superiority. In 1775 a patriotic association was formed at Edinburgh to discourage ladies from wearing the cotton robes of India in preference to the calicoes and lawns of Glasgow and Paisley.

By the year 1727 the cotton industry had so far

developed as to enable Defoe, writing on Manchester, to say "the grand manufacture which has so much raised this town is that of cotton in all its varieties." By 1750 there were in and about Manchester over 30,000 people engaged in the cotton industry, and the woollen and linen industries were also pursued on an extensive scale, not only here but in other parts of Lancashire. There, then, was laid the foundation of that industry which has built up the great wealth and industrial pre-eminence of Lancashire. In Dr. Aikin's *Forty Miles Round Manchester*, published in 1795, he says, speaking of the recently introduced cotton industry, "that in the middle of the previous century the Manchester traders went regularly to buy fustians[1] (a coarse cloth) of the weaver, each weaver then producing yarn or cotton as he could." Then he goes on to say that three-quarters of a century afterwards "the Manchester merchants began to give out warps and raw cotton to the weavers, receiving them back in cloth, and paying for the carding, roving, spinning, and weaving." Next there arose "second-rate merchants, called fustian-masters, who gave out a warp and raw cotton to the weaver, and received them back in cloth, paying the weaver for the weaving and spinning, and these attended the weekly market at Manchester, and the middleman sold his pieces in the grey to the merchant, who afterwards dyed and finished it." The system was primitive, but it gradually spread over the hills, dales, and plains of Lancashire, and in other places. Very many of the farm-houses and cottages had their weaving shops, and the cellars of many labouring people in the towns and villages contained hand-looms. The cotton wool was, at the outset of the system, picked by the young children, and it was then carded and spun on the jennies by the elder girls or the good wife, the yarn being woven by the father or the sons. The women of the district were sometimes engaged by the hand-loom weavers, for one efficient, industrious

[1] The term "fustians" at this period consisted of "herring-bones, pocketing, strong ribs, thicksets, and lining jeans."

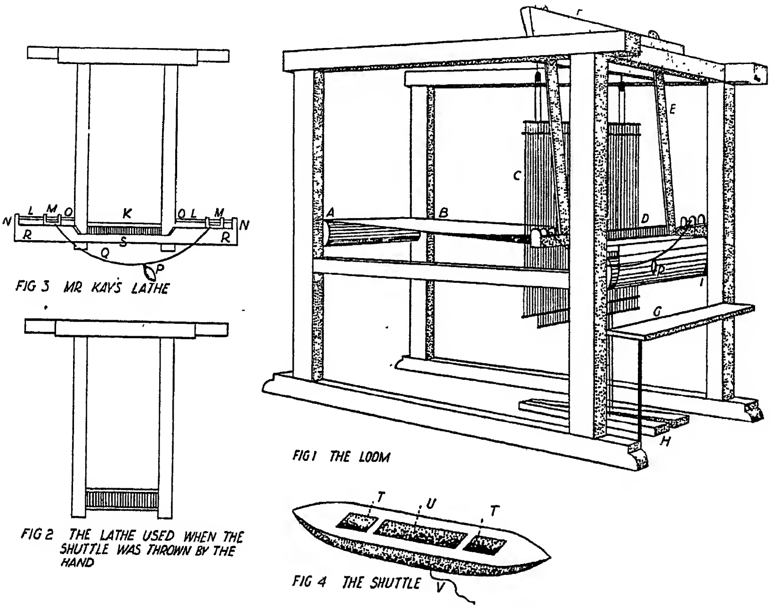
weaver could keep three women busy turning weft off the spinning wheels. It was often difficult to get weft, and the weaver was frequently unable to deliver his cloths to the manufacturers within the time he had contracted.

Postlethwaite, in his *Dictionary of Trade and Commerce*, in 1766, estimated that at Manchester, Bolton, and in the neighbourhood over £600,000 worth of cotton goods were made annually. Fustians, cottons, tapes, etc., were sent on pack-horses to London, Liverpool, and Bristol for exportation. Manchester men travelled to different parts of the kingdom to sell cloths to the tradesmen for home consumption. Baines tells us that "up to the year 1760 the machines used in the cotton manufacture in England were nearly as simple as those of India, though the loom was more strongly and perfectly constructed and cards for counting the cotton had been adopted from the woollen manufacture." It was clear that means would have to be taken to multiply the yarn supply, or the expanding trade was in danger of being lost. The genius of inventors was first spent in the development of the domestic spinning wheel.

In 1733 John Kay invented his fly-shuttle, Figs. 1–4, and the invention may be said to have been the beginning of the great machine age in textile development. This invention greatly increased the production of a loom. Even before this time the supply of weft yarn was very slow; so the shortage was now very great, and attention was directed to increasing the supply. It required the production of three spinners to supply one weaver, and, as Kay's invention increased the looms' output about fourfold, there arose an angry protest from the operatives, who drove him from his home to Leeds. He later on returned to Bury and invented a spinning machine which is thought to have anticipated the machines of Arkwright and Crompton. This new machine also aroused the fury of the cotton workers, who destroyed the machine, and Kay only saved his life by his flight to France.

Kay's Hand-loom.

Kay's loom, or the loom that preceded the power-loom (according to Richard Guest), is shown at Figs. 1–4. The warp is wound upon the yarn beam *A*; the lease is carefully preserved by rods *B*; one-half of the threads pass through one heald, and the other half through the other.



Kay's Loom

The healds *C* are looped in the middle, and the threads of the warp go through the loops, and then through the dents of reed *D* fixed in the movable frame, called the lathe *E*. The lathe swings on the cross-piece *F* on the upper part of the loom. The weaver sits on the seat *G* and, with his foot, presses down one of the treadles *H*, which raises one of the healds *C* and each alternate thread of warp. The weaver holds the picking peg *P* in his right hand, and with it drives the shuttle from one side of the lathe to the other, between and across the threads of the warp. As

the shuttle passes between the two rows of warp threads it leaves a pick of weft behind. By the weaver pulling the lathe towards him with his left hand this pick of weft is driven close to the edge of the cloth. The cloth is wound upon the cloth roller *I*.

Fig. 2 illustrates the lathe as used before John Kay invented his fly-shuttle, Fig. 3. With Fig. 2 lathe, the shuttle was thrown by hand. In Fig 3 *K* is the reed, *LL* are iron rods, and *MM* are movable slides which work from *N* to *O* along rods *LL*, and which are attached to the picking peg *P* by cord *Q*. *RR* are the shuttle boxes, and the weaver, by a sudden jerk with the picking peg, moves slide *M* from *N* to *O* and drives the shuttle along the shuttle race *S* into the box *R* on the other side.

The shuttle, Fig. 4, has small wheels *TT*, on which it moves along the shuttle race. The weft *U* is wound upon a skewer and fixed in the shuttle. As the shuttle flies across the warp the weft unwinds from the skewer and runs through a small hole *V* in the side.

It was not till 1764, thirty years later, that James Hargreaves, of Stanhill, near Blackburn, invented his spinning jenny, which was driven by a fly-wheel, and held a number of spindles slightly inclined from the perpendicular, a movable frame receding from the spindles during the extension of the threads and approaching them in its winding on. The first machine had only eight spindles, then sixteen, and eventually the number was increased to eighty.

The spinning jenny supplied a long-felt want—of producing more yarn—and it spread rapidly all over Lancashire. By its use one spinner could easily spin as much yarn as had been formerly spun by thirty to forty spinners. The alarm of neighbours lest it should destroy hand labour led them to break into the house and destroy the jenny. Hargreaves left the district and went to Nottingham in 1768, where a joiner named Thomas James entered into partnership with him to erect a spinning mill on the jenny plan. Before patenting the jenny he found

his machine had been extensively pirated in Lancashire. He died in 1778. Crompton, the inventor of the mule, learned to spin on one of these jennies in 1769. It was in that year that Arkwright, the Preston barber, secured his patent for a system of spinning by rollers, not a new idea, it is true, for a patent for a system of this sort had been taken out in 1738 by Lewis Paul.

John Wyatt, of Birmingham, about the year 1738 invented a machine for spinning by rollers, in which year it was patented by Wyatt's partner, Lewis Paul, who was a foreigner. This specification is probably still in existence. The imperfection in mechanism prevented its general adoption. Arkwright's mechanism was much more perfect, and he and his partners began a little factory at Nottingham.

Arkwright's system was widely adopted and used for spinning warp and hosiery yarns of a hard and compact fabric, of any grist up to seventy or even eighty hanks in the pound. Hargreaves's system spun soft weft yarn of rather inferior numbers, and these two independent systems for many years produced the cotton yarn of the country. The jenny gave way to the wonderfully clever invention of Samuel Crompton, of Bolton—the spinning mule. Ure says: "In the place of Arkwright's bobbins and flyers Mr. Crompton used the spindle carriage of Hargreaves's jenny to receive, attenuate, twist, and wind on the threads, after their emergence from the drawing rollers."

Crompton's invention was for some time called the "Hall-in-the-Wood Wheel," as well as the "Muslin Wheel," this latter name because it made yarn fine enough for muslins, as yarn up to 80's was spun upon it, which at that time was a wonderful performance.

Crompton did not protect his machine by taking out patent rights, so it was rapidly taken up by manufacturers. The adoption of this mule, as improved by Henry Stones, a clever mechanic residing near Bolton, was followed by developments immensely increasing the volume of production and the fineness of the yarn. About this time

there was invented the billy, a union of jenny and mule, by a Stockport man. The widely adopted mule was from time to time improved by various devices. For some time roving was a distinct business in the hands of those using Arkwright's carding and roving machines. They disposed of the rove to the hand mule spinners. The new devices gave a great impetus to the factory system.

In his *History of the Rebellion* Marchant says, in 1745, "The fustian manufactures called Manchester cottons, for which it has been famous for almost one hundred and fifty years, have been very much improved of late by some inventions of dyeing and printing with the great variety of other manufactures, known by the name of *Manchester goods*, as ticking, tapes, filleting, and linen cloth, enrich not only the town but the whole parish, and render the people industrious."

In 1760 Manchester began to be famous for cotton manufacture, ginghams, moreens, and other goods which totalled £200,000 per annum.

In 1763 muslins, both striped and plain, were first manufactured by Mr. Shaw at Anderton, near Chorley, and cotton quiltings at Bolton.

The year 1769 saw the beginning of the great improvement in the cotton trade, for in this year Arkwright, in partnership with Samuel Need of Nottingham, and Jedediah Strutt of Derby, erected a mill at Nottingham for the new machines, which were turned by horses. This proved too costly, so they built another mill in 1771 at Cromford, and speedily the expansion of spinning began on Arkwright's principle, in various parts of Lancashire especially. Inventions to expedite cloth production began at an earlier date In 1738 John Kay, of Bury, invented the fly shuttle, a picking stick driving the shuttle instead of the old method of hand throwing. (See Figs. 1 to 4.) In 1760 Robert Kay, the son of John, invented the drop box to accommodate shuttles holding threads of various colours. In 1760 the swivel loom, adopted from the Dutch, and weaving a number of narrow pieces (tapes, etc.) at

the same time, was introduced. Then came the invention of the harness-loom for figured goods, and this was subsequently superseded by the Jacquard loom, with its elaborate system of perforated cards. The commencement of the factory system began with master weavers who employed children, apprentices, and journeymen. Some employers had looms on their premises and engaged weavers. From the ranks of these rugged, strong men, with the northern grit and grand spirit of self-reliance, there emerged in time some of the richest cotton lords of Lancashire and the far North; for Scotland, the land of education, progress, and lusty men, had taken up cotton manufacture in several places at an early period. For a time the domestic system prevailed in manufacturing.

The inventions to increase the output of yarn succeeded so well that loom improvements became an absolute necessity.

In order to encourage the home manufactures it was enacted in the year 1774 that all tools and utensils used in any of the several processes of spinning, weaving, and dyeing should be prohibited from exportation, under the penalty of £200 to be paid by the shipper, and a similar sum by the commander of the vessel receiving them on board (XIV, Geo. III, c. 71).

In 1785 the Rev. Edmund Cartwright obtained a patent for a power-loom so constructed that it required the strength of two powerful men to work it at a slow rate and only for a short time. Realizing that this loom was far too costly to run, he then perfected the machine, and on 1st August, 1787, he patented the power-loom as we now know it. He established a power-weaving mill at Doncaster, but the loom required so much alteration that he spent nearly £40,000 in effecting and patenting his further improvements. This mill was eventually abandoned. Following this, in 1791, a factory was erected in Manchester to contain four hundred power-looms, and no sooner was it erected and a few looms at work than the building and machinery were wilfully destroyed by fire.

Nothing further appears to have been done with the power-loom till 1798, when it was applied at Glasgow to the weaving of cotton fabrics.

In 1820 only about 14,000 power-looms were in use in the United Kingdom, whilst the number of hand-looms approximated a quarter of a million. Subsequent to 1836 the power-loom became rapidly adopted, and this was largely due to the economical advantage of the invention of Radcliffe and others to enable the warp to be dressed before it went to the loom, instead of the loom having to be stopped to dress the warp. The loom, too, was improved by the cloth being taken up mechanically instead of having to be pulled forward by the weaver. Other improvements, which will be dealt with later, perfected the loom to that high degree of automatic mechanism which we see in the power-looms of to-day.

Following the erection, in 1770 at Nottingham, of Arkwright & Partners' horse-driven mill there was, in 1771, built at Cromford, in Derbyshire, Arkwright's larger mill, driven by water-wheel (which gave to Arkwright's invention the common title "water-frame"). Between 1776 and 1778 half a dozen mills were built in Oldham, three worked by horses and three by water-power.

About 1780, in consequence of the numerous outrages that had occurred in the manufacturing districts, the destruction of cotton, as well as other textiles, etc., was made *felony*, which enactment had the salutary effect of arresting the progress of this unpleasant species of crime.

Then the mills spread over Lancashire, being often placed in the valleys to get the advantage of the water-power from the rivers and their tributaries, which transformed peaceful vales into busy and well-to-do communities.

The year 1783 was an important one in the history of cotton, for the bounties as follows gave great encouragement to manufacturers. It was enacted that bounties were to be paid, free of any fee, and without any other

deduction whatsoever, upon exportation to Africa, America, Spain, Portugal, Gibraltar, or the East Indies, viz. of British calicoes, cottons, and cottons mixed with linens printed, stained, or dyed, in Great Britain, not less than 25 inches broad, if the value, independent of colour or figure, was under 5d. per yard, ½d.; if 5d. and under 6d., 1d.; and if 6d. and not exceeding 1s. 6d., 1½d.; and to continue in force till 28th March, 1784.

Then came the invention of Watt's steam engine, applied first in 1785 to a cotton mill at Pepplewick. It was adopted in Bolton and Glasgow, and next in Oldham. Water-power was gradually substituted by the steam engine, and there was seen more and more the concentration of factories and weaving sheds in towns and valleys. Hand-loom weaving gradually declined, the putting-out shops and the weaving rooms were closed one by one, and the stalwart, self-reliant weavers came into the towns and villages, and lived the busy life of the operative, whilst the farmers' sole business became attention to the agricultural arts and stock-breeding, whereas formerly it was divided between weaving cloth and cultivating the land. Cotton manufacturing had continued to increase so rapidly that in 1788 it was estimated that 159,000 men, 90,000 women, and 101 children were employed in the trade around Manchester. Two years later power-looms were introduced in that town, and from this year began the revolution.

It was a peaceful revolution, fruitful in blessings and prosperity. Our trade expanded in all directions, and the Exchange at Manchester became the great emporium of the world for the distribution of cotton goods, both fancy and plain. One cannot attempt to encompass in an epitome all the inventions in the mechanical arts bearing upon cotton-trade evolution and expansion. We in this kingdom got the start of the world, and our home market, our colonies, and possessions beyond the seas became our bountiful patrons. Production multiplied apace. Lancashire especially grew abundantly in riches and power

under the textile system. Swift rail and sea transport came in as an auxiliary of trade development, and the huge mercantile system brought out some of the ablest, most enterprising, and most honourable men of the nation. The trade has had its periods of prosperity and depression, of strikes and lock-outs, which can only be thus generalized. It has had to face a yearly growing competition from Continental nations and from both the Northern and Southern States of America, and even the Far East, especially Japan, competes in the world markets.

The wide adoption in England of the co-operative principle has largely transformed mill ownership and stimulated industrial development. Legislation has improved the lot of the worker from time to time. Consolidation, centralization, and specialization are more and more yielding economical and commercial advantages. There has been a gradual co-ordination of forces. The operatives began their unions in the early days of the factory system. Then Masters' Associations were formed. Now the workpeople in the spinning, cardroom, and weaving and other branches, have their separate organizations, all very powerful, and for certain objects federated. The employers have had to lengthen their cords and strengthen their stakes. They have great district Associations and a Federation, the most powerful in the world, of the Master Cotton Spinners' Associations. The operatives spread their organized work to international proportions, bringing into line for common objects operatives of all Continental nations with themselves. The employers have followed their example, and have founded one of the greatest organizations the world has known—the International Federation of Master Cotton Spinners' and Manufacturers' Associations. These organizations are referred to in the final chapter.

Size of the Cotton Industry

The total estimated number of raw cotton spinning spindles in work in 1933 is given in the following table.

The other facts set forth in the table also illustrate the enormous magnitude of the cotton industry to-day.

	Mills	Spindles	Looms	Operatives	Cotton Consumption
EUROPE *excluding Russia*					Million lb.
United Kingd'm	1,790	50,167,000	600,000	518,000	1,133
Germany .	1,640	9,846,000	250,000	268,000	582
France . .	1,320	10,170,000	200,000	230,000	486
Italy . .	1,090	5,357,000	152,000	245,000	404
Czechoslovakia	700	3,627,000	150,000	120,000	161
Belgium .	220	2,096,000	54,000	40,000	134
Spain . .	400	2,070,000	75,000	100,000	216
Poland . .	70	1,797,000	40,000	40,000	117
Switzerland .	55	1,306,000	25,000	25,000	49
Holland . .	121	1,225,000	55,000	40,000	71
Austria . .	72	763,000	14,000	20,000	46
Sweden . .	75	593,000	15,000	16,000	53
Esthonia .	2	552,000	10,000	13,000	50
Portugal .	153	446,000	25,000	22,000	34
Finland .	30	264,000	7,000	8,000	15
Hungary .	59	257,000	12,000	12,000	35
Others . . .		520,000	33,000	30,000	30
TOTAL .		91,000,000	1,720,000	1,750,000	3,600
Russia—(U.S.S.R.) .	210	9,200,000	250,000	500,000	591
ASIA					
India . .	339	9,506,000	182,000	395,000	1,145
Japan . .	3,980	7,965,000	277,000	290,000	1,306
China . .	127	4,493,000	44,000	150,000	1,216
Others . .		245,000	3,000	12,000	41
TOTAL .		22,200,000	490,000	850,000	3,710
AMERICA					
United States .	1,280	31,255,000	654,000	468,000	2,522
Canada . .	33	1,261,000	24,000	21,000	86
Mexico . .	170	830,000	31,000	40,000	62
Brazil . .	369	2,694,000	126,000	150,000	183
Others . .		270,000	15,000	20,000	21
TOTAL .		36,300,000	850,000	700,000	2,870
GRAND TOTAL		158,700,000	3,310,000	3,800,000	10,771

MILLS. Establishments engaged in spinning or weaving. Figures are not always comparable owing to the arbitrary exclusion of small concerns, e.g. in the United Kingdom of firms employing 10 persons or less, and, in Japan, of weaving concerns with less than 10 looms.

SPINDLES. Figures refer to the number of spinning spindles on 31st January, 1933, according to the International Federation of Master Cotton Spinners' and Manufacturers' Associations.

LOOMS. Figures refer to power-looms and are the latest available.

OPERATIVES. Figures include operatives employed in finishing operations if occupied in a spinning or weaving concern. The number given is the average number employed in a normal year or, alternatively, the number allotted to the cotton industry in a recent count.

COTTON CONSUMPTION. Figures are for the year ending 31st January, 1933.

These cotton trade statistics have been prepared by the Economic and Statistical Department of the Joint Committee of Cotton Trade Organizations, Manchester.

There are quite 6,000,000 doubling and waste-cotton spindles, besides the above raw cotton-using spindles.

The total estimated number of looms in the United Kingdom and Ireland is about 600,000. It is very difficult to estimate the number of looms abroad, on account of the large number of hand-looms still in use in some parts of the world; but, roughly speaking, there must be 2,710,000 power-looms in the world, besides the 600,000 of Great Britain, employing 3,800,000 operatives (including spinning operatives) and consuming 10,771,000,000 pounds of cotton annually.

It was stated by the late Sir Charles W. Macara, Bart., a former Chairman of the Committee of the International Federation of Master Cotton Spinners' and Manufacturers' Associations, that the cotton industry manipulates raw material in one year of the value of over £200,000,000, and that it distributes throughout the markets of the world manufactured goods of the value of £450,000,000, or 11,250,000,000 francs. This statement was made in 1908.

Up to the early 'seventies England occupied a preponderating position in the cotton industry; this, however, has entirely changed, as is seen from the preceding table.

Speaking in Zurich in 1904, on the occasion of the foundation of the International Cotton Federation, the

late Sir Charles W. Macara gave the following interesting particulars—

There is little doubt that the expansion of cotton machinery throughout the world has been so great that for four successive years the supply of the raw material has been insufficient to run the cotton spindles of the world.

There is no industry in Great Britain, excepting agriculture, which affords so much employment, directly and indirectly, for the masses of the people as the manipulation of cotton, or which is of more importance to the whole mercantile and industrial system of England.

Estimating the raw cotton at an average value of 5d. per lb., £40,000,000 worth is imported annually, an average of about £5,000,000 worth is re-exported in the raw state, leaving the balance of £35,000,000 worth of cotton to run the spindles and looms.

This cotton, after being converted into yarn or cloth, and after undergoing one or more of the further processes of finishing, bleaching, dyeing, printing, making up into pieces, or being converted into ready-made garments, is finally packed and disposed of by the distributors at home and exporters at an estimated value, on the same basis, of over £90,000,000, leaving, as will be seen, a balance of over £55,000,000 to pay imperial and local taxation, profit on capital invested, depreciation on buildings and machinery, coal, mill stores, etc., and wages, this last item representing by far the largest proportion of the £55,000,000. The raw material is largely brought to England by British ships. When landed at the ports it forms an important part of the mercantile transactions of these ports, and the warehousing and handling of it employ a large amount of labour. The carrying of this raw material to the cotton-spinning mills forms a substantial source of revenue to some of the most important railway companies and to the Manchester Ship Canal. In the further carrying of the yarn to mills engaged in the weaving branch of the cotton industry another large source of revenue accrues to the railway companies and other carriers.

Owing to the great variety of cotton goods produced in England the majority of manufacturers have to supply their requirements from numerous spinners, there being comparatively few mills that combine both processes of spinning and weaving.

Again, the grey cloth has to be carried to the warehouses of the distributors or to the works of the finishers, dyers, printers, bleachers, and ready-made clothing manufacturers; these further processes involving another rate for the railway companies before the goods reach the warehouses of the distributors, who finally are responsible for their distribution to the home and foreign markets; this again bringing in further revenue to the railway companies, shipowners, and other carriers. Like the handling of the raw material, the distribution of the manufactured products

of the spindles and looms forms another important part of the commercial transactions of the nation, more especially as regards Lancashire.

From the standpoint of employment, a study of the position is even more impressive. As already stated the handling and warehousing of the raw material at the ports find employment for a large number of people. The repeated carrying in connection with the various processes of manufacture gives employment to a much larger section of the population.

The cotton operatives engaged in spinning and weaving number, in round figures, 500,000. The number employed in the subsidiary industries and employments connected with cotton, already enumerated, is more difficult to estimate, but it will amount to another 500,000. Allowing two dependants only to each worker (there being a large number of young people employed) a population of no less than 3,000,000 is represented.

There are further the dependent industries, such as the great machine-making and engineering establishments, which are largely employed with repairs, renewals, and extensions in the British cotton and subsidiary industries, also a portion of the mining and chemical industries; all of which represent a further section of the population. The provision trade is obviously mainly dependent on the masses of the people. In any dislocation of the cotton industry its serious effects on employment generally would be widespread. But it would not end here; the retail, mercantile, banking, professional, and leisured classes would all suffer severely, and so would the landowners, property owners, and the agricultural classes, who find their largest markets in the great mercantile and industrial centres of the North of England.

CHAPTER II

COTTON GROWING

THE word "cotton" may be traced to the language of Arabia, a country where the plant is indigenous. Cotton was doubtless used for clothing in the very early days of human history. It was introduced into Western Europe at the era of the Mohammedan conquest, and, as a matter of fact, it was in Mohammedan Spain that cotton manufacture first began in Europe.

Cotton was well known and in common use in India long before the Christian era, for in a book written about 800 B.C. the plant is referred to frequently, and in such a way as to show that it was quite familiar. About 200 B.C. cotton reached the shores of the Mediterranean, and in the year 70 B.C. it is recorded that the Romans used tents, awnings, and canopies made of cotton.

Pliny writes about the cultivation of cotton in Upper Egypt, and mentions that the priests' garments were made of cotton in A.D. 70. Nearchus, the admiral of Alexander the Great, who took part of his army along the shores of the Arabian and Persian Gulf about 327 B.C., says: "There are in India trees bearing as it were branches of wool. The natives made linen garments of it, wearing a shirt which reached to the middle of the leg, a sheet folded about the shoulders, and a turban rolled round the head, and the linen made by them from this substance was fine and whiter than any other." Our word "calico" was originally given to this familiar material because it came from the Indian port of Calicut. From India cotton plants were probably sent to China and other neighbouring countries.

It is recorded that in the year A.D. 970 cotton cultivation and manufacturing was firmly established in Spain. England during the thirteenth century imported cotton, but only for use in the making of candle wick.

Later explorers found cotton in other regions. For example, in 1492, Columbus noted that it grew abundantly in the West Indies and on the neighbouring coasts of America, and that the natives had considerable skill in making it up into cloth. In Mexico, Peru, and Brazil cotton was well known, and in Mexico it was the chief article of clothing. In parts of tropical Africa cotton grows wild, and is used by the natives to make cloths.

Cotton belongs to the order of the *Malvaceae*, or mallows, its generic name being *Gossypium*. It is, therefore, related to the English hollyhock, which it remotely resembles.

Experts in systematic botany differ greatly as to the number of separate species which can be distinguished, but the following are generally recognized—

(a) Group of Old World or "Asiatic" Cottons.

Gossypium herbaceum. This includes most of the Indian and Levant cottons, and the native types of Russia, Turkestan, and Persia.

Gossypium arboreum or tree cotton. Although tree cottons are found in other sections also, this name is usually restricted to a type resembling the Asiatic, and includes the sacred tree cotton of India.

(b) Two Groups of "Non-Asiatic" Cottons.

1. The Upland Group. *Gossypium hirsutum* is so called from the hairy character of the plant, in stem, leaves, and seed. The American Upland is the chief representative of the group, to which the Indian Cambodia cotton also belongs. The group is possibly also Asiatic in origin, though its most important cultivation is now in the New World.

2. The Peruvian Group. *Gossypium barbadense, maritimum,* and *peruvianum.* This group includes the Sea Islands, Egyptian, Peruvian, Caravonica, and other cottons. The exact origin of these forms, which include the best kinds of lint on the market, is uncertain. They

may also be roughly distinguished as the "vine-leaf" cottons.

In appearance and growing characteristics the cotton plant varies greatly in different countries, but it may be described as generally a bushy plant, growing about 3 to 6 ft. high, with more or less widespreading branches, especially on the lower portion of the stem, and tapering to a pointed top. When closely planted, the development of the branching is reduced, and the plant grows more like a raspberry bush than a gooseberry. The root system also differs greatly according to the nature of the soil and the water supply. In Egypt, for example, the main tap-root has been known to descend over 6 ft. into the ground in search of water, and it is probable that it would do the same elsewhere if conditions allowed. While, therefore, cotton does grow well on shallow soils (as in Barbados), it does much better in deeper soils.

The leaves are large, and more or less deeply divided into three or five lobes, the form differing greatly in the different species and varieties. Thus, Sea Island has very deeply cut lobes, while American Upland represents the opposite extreme, more like an ivy-leaf, but covered with hair, which gives it a dull appearance. The Indian leaf is smaller, with lobes characteristically rounded in appearance.

The flower also differs considerably in colour from one species to another. It resembles generally the flower of the hollyhock in shape, but is more tubular, and is surrounded by three large bracts, or outside leaves. The flower of the Sea Island and most Egyptian types is lemon or golden-yellow, with crimson spots at the base of the five petals inside, and a golden brush of stamens; but that of the ordinary American Upland is creamy, usually without any markings, and has buff-coloured stamens.

The Indian flower is also yellow, but smaller than the Egyptian, and the spots are larger and darker. The flower of the sacred cotton tree, and of some other varieties

in India, is red. In fading, if the atmosphere is humid, the yellow flower turns pink, and finally almost red, before it withers. It only remains open for one day.

The boll, or fruit, before maturity, is of varying shades of green, and differs very greatly in size—from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. in diameter—and in shape in the different varieties. Thus, the Sea Island and Egyptian bolls, especially the former, are narrow and pointed; while the American Upland is much rounder and appears much shorter. Some of the new varieties of medium staple American cotton have very large but pointed bolls.

The boll is divided into from three to five *loculi*, or compartments, each containing a "lock" of seven to nine seeds, to which the lint—the actual cotton itself—is attached. Here, again, is a marked difference, according to the species and variety. The Sea Island and Egyptian seeds are black or brown, and the lint comes easily and completely away from the seed in the process of "ginning," or separating the lint from the seed, except for a small tuft of short fuzz at the point in certain varieties. They are, therefore, known as "black" or "clean" seeds. In the American Upland and Indian varieties, on the other hand, there are two kinds of hair: one—the actual cotton or "lint"—being about an inch in length, and coming away easily from the seed in the "gin"; the other is a short fuzz, which adheres very closely to the seed, and is only partially removed, even by the subsequent process of "delinting." What is removed by this process is known as "linters," and forms an appreciable, though, until the War, not valuable, addition to the American crop. Its most important use during the War was as the raw material of gun-cotton, but it is now increasingly used for the manufacture of cellulose, the raw material of many new industries, e.g. artificial silk. These seeds are known as "white" or "fuzzy."

The length, strength, fineness, and character of the lint are, from the spinner's point of view, the characteristic distinguishing marks of the different varieties. Sea Island

staple, for example, often exceeds 2 in. in length; Indian, on the other hand, may be less than $\frac{1}{2}$ in.; while the diameter of the fibre varies from 0·0007 to 0·0001 of an inch. The appearance of the lint in the open boll also varies immensely, from one type of Indian, in which, when ripe, the contents of the boll hang right out to the length of 2 or 3 in., like a bunch of grapes, to that of the Sea Island, in which the lint clings closely to the lock in a peculiar curled condition, like raw silk.

The seed generally forms about two-thirds of the gross weight of the seed cotton, and the lint one-third; but this proportion, or "ginning out-turn," is much lower in the case of many varieties and higher in others—varying from 25 to 50 per cent.

The climate most suitable to cotton-growing may be described as sub-tropical. The period of growth of the plant from sowing to picking is about four to eight months, but in many cases the picking season is very long drawn out. Cotton requires an ample water supply, which may be derived from natural rainfall or from irrigation. It is important to notice how rapidly the growth of cotton under irrigation has developed in modern times. Cotton was certainly at first a rain crop (i.e. a "monsoon" crop) in India; but the quantity of cotton grown under irrigation in every part of the world is now very large. Indeed, it appears that the best growing conditions can only be secured by irrigation. In America, for example, the crop suffers very seriously in certain seasons owing to damage by untimely rain, which stains or "tinges" the ripe cotton and materially lowers its value; while, on the other hand, where irrigation is not possible, the crop is liable to serious damage by drought during the growing period.

Where the growing season is likely to be prematurely closed by severe frost the amount of the crop is liable to severe fluctuations. In America, for instance, the date of the first killing frost in autumn is often the determining factor in the final yield of the crop. Frost, on the other hand, is the worst enemy of certain insect pests which

prey upon the cotton, such as the boll weevil in America. Again, the extermination or reduction of such pests is often assisted by summer droughts: for most of them seem to flourish best under moist, shady, and relatively cool conditions.

The cotton crop requires a considerable amount of intensive cultivation at certain periods. Thus, after sowing, it requires to be "chopped" or thinned out, and the ground carefully "cultivated" (hoed) to keep it clear of weeds, and also to prevent unnecessary evaporation of the moisture of the soil. There is usually a period before final harvesting when the crop is "made," or "laid by," as it is called in America, and requires little attention until picking time arrives. Picking itself requires an immense amount of labour, which, indeed, is in many cases the limiting factor in the extension of the crop. Thus, on the whole, cotton is essentially a cheap-labour crop, and the best results are obtained when hand labour can be used throughout, as in Egypt.

The methods of picking, ginning, baling, handling, and selling the crop vary greatly in different countries. One of the two main methods of ginning is by the roller gin (see Fig. 8, page 56), which is used in Egypt and the Sea Island districts, and generally wherever long staple cotton is grown. By a strange paradox, it is also very largely used in India, even for the shortest stapled cotton. The great bulk of the world's cotton, however, is ginned by the American sawgin. (See Fig. 9, page 57.) The character of these two types of machine is sufficiently indicated by their names. In certain parts of Russia, China, and India a peculiar type of cotton is grown which, owing to the in-growing habit of the lint, must be plucked bodily from the plant and the lint extracted at leisure afterwards.

From the side of supply as well as demand the world's cotton market has increased in complexity and specialization during the last twenty years as greatly as it has in bulk and extent. The Weekly Circular of the Liverpool

Cotton Association before the War quoted the prices of no less than forty-six different varieties of cotton, of which 4 were American, 5 Peruvian, 6 Brazilian, 2 West Indian, 6 Egyptian, 2 African, 19 Indian, and 2 miscellaneous (Chinese and Levant).

All of these have their own peculiar qualities and special uses, and the range of values is very wide. Thus in July, 1914, Liverpool prices varied from, say, 4d. per lb. up to 40d. per lb., with the basis price of American Middling about 7d. Most of them are specially adapted for and are mainly employed in particular trades. All of them, however, are more or less interdependent, as to both supply and demand. There is a good deal of overlapping in the supply of different varieties—areas may, and do, grow one variety or another at different times, according to varying conditions or the movement of prices. Thus, the parts of the Carolinas and Georgia which formerly grew Sea Island are now growing short staple Upland, and much of the area in Arizona which formerly grew Pima (American-Egyptian) cotton was in 1924 turned over to short-stapled American varieties. On the other hand, there are increasing possibilities of substitution of one variety for another in spinning, such as the substitution of American long staple for Egyptian cotton, or of the better grades of Egyptian for Sea Island.

For the sake of clearness, some system of classification of the different varieties of cotton into broad grades must be attempted, though it must be understood that no such classification exists in practice in the trade, and that the limits of the different classes are by no means clear or exact. The writer has attempted to frame such a classification, taking the different classes of cotton according to their quality or spinning capabilities.

Formerly this classification was into five grades, but the virtual disappearance of Sea Island cotton has made it desirable to modify the classification into three grades as follows.

Grade 1. The best cotton of all is the true Sea Island (Fig. 5), formerly grown on the islands (hence the name) off Charleston, South Carolina, and also in the West Indies. The total quantity of these crops was never very large, the average total being less than 100,000 bales per annum, but their value was very high on account of their marvellous spinning qualities. The best Sea Island can be

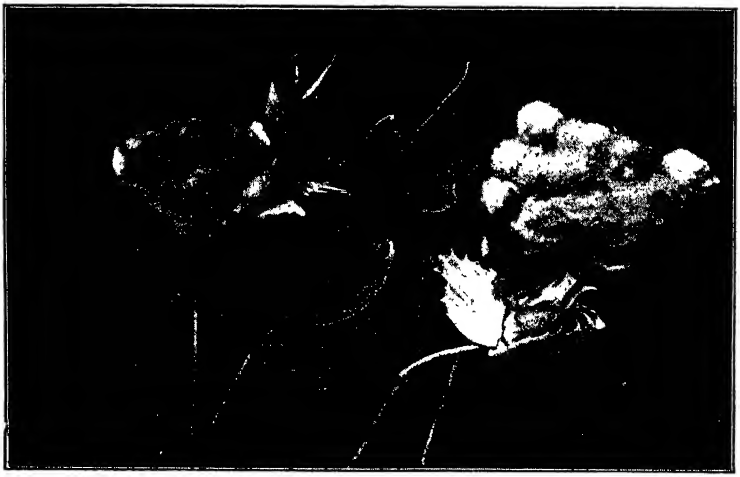


Photo by *Newton & Co.*

FIG. 5. SEA ISLAND COTTON

spun as high as 300's or even more, which means that 150 miles of the yarn spun from such cotton weigh only 1 lb. The use of such fine yarns was, of course, confined to the very highest grades of fabrics and the finest sewing cottons. They were largely employed in the Nottingham lace trade.

Next to these came certain grades of Sea Island, grown in Georgia and Florida, which were of excellent quality, though not so superfine as the real "Islands."

But the advent of the boll weevil in the Atlantic States about 1917–18 produced, as had been anticipated, the most disastrous effect on the Sea Island districts, and

most of the planters immediately abandoned the attempt to fight the weevil. Efforts were made to introduce a long staple Upland cotton, namely "Meade," which had the advantage of earlier maturity, but this met with very little success, and now practically the whole of these old Sea Island districts has been turned over to short staple cotton. In 1924 no separate statistics were given of Sea Island cotton, but it was reported that only 2,361 bales had been grown. There is still a small quantity of the super Sea Island variety grown in the West Indies (see page 29).

The fine cotton trade has therefore been compelled to resort to Egyptian cotton as practically the sole source of its supply. Before the War Egypt was producing a number of very fine cottons, such as Abbassi, Jannovitch, and, latterly, Sakel, which were second only to the finest Sea Island in quality and spinning capabilities. They were also extra strong, which gave them certain special uses of their own where strength and fineness were essential. Since the War, Abbassi and Jannovitch have practically disappeared and Sakel has become the dominant variety in the Delta, where the best Egyptian cottons have always been grown. Next to these superior grades of Egyptian came the ordinary varieties of Egyptian cotton, i.e. Nubari, Afifi, or Brown Egyptian, and Ashmouni, or Upper Egyptian. But here again the post-War period saw great changes. Nubari and Afifi gave place almost entirely in the Delta to Sakel, so that the Egyptian crop became roughly divided into two main varieties, Sakel and Ashmouni or Uppers, and as time went on the line of demarcation between these two became less definite owing to the progressive deterioration of Sakel, and the production of new varieties of Uppers, especially Zagora. As will be seen later on, in 1924 Zagora invaded the Delta owing to the temporary disappearance of the premiums on Sakel in the previous season, although this movement has since been less noticeable.

As far back as 1909, when the Egyptian premiums first

went to prohibitive levels, Egyptian spinners found themselves forced to experiment with other supplies of fine cotton, and had conspicuous success with certain of the best varieties of American long staple Upland cotton, especially those known as "Peelers" and "Benders," grown in the Mississippi Delta (see page 33). For many purposes, including even mercerizing, which had long been supposed to be exclusively confined to Egyptian, these long staple American varieties proved themselves almost as good as Egyptian, but, unfortunately, the boll weevil reached the Mississippi Delta in 1909–10 and the supply of these long staple varieties quickly disappeared. Their place was taken, however, to a certain extent by improved varieties of early maturing Upland cottons, some of which, through careful breeding, attained a staple of 1¼ in.; and since the War these new varieties have played a very important part in taking the place of Uppers when Egyptian prices went to excessively high figures.

Finally, it is necessary to include in this first grade, though towards the lower end of it, much of the Peruvian cotton, a considerable amount of the best Brazilian, and some of the best of the new African cottons.

Grade 2. The great bulk of the world's cotton supply, however, consists of the ordinary American Upland crop, which still amounts to about 58 per cent of the whole world's crops. This has, of course, no rival in the matter of quantity, but there are various smaller crops which are round about the same quality (e.g. Brazilian, West African, Russian, Asia Minor, and, in recent years, some of the improved varieties of Indian cotton). Some of the Chinese crop may also be included in this grade.

Grade 3. The greater part of the Indian crop is in a grade by itself, of a very short staple and inferior quality. It is little used in Lancashire, but is largely employed in the local mills of India, in Japan, and also in most of the Continental spinning countries. Similar to the Indian crop in quality are certain of the native varieties of Russian cotton. Finally, the great unknown of the cotton

THE WORLD'S COTTON SUPPLY AND THE BRITISH EMPIRE'S SHARE IN IT

(in 000's of 500 lb. bales, approximate)

Variety	Where Grown	Length of Staple	Approximate Crops: Pre-War	Approximate Crops: 1933–1934 (Estimates)	British Empire
GRADE I—FINE		Inches	Bales, 000's		
Sea Island . . .	West Indies (British)	$1\frac{1}{2}$–2	6	2	2
	Charleston, South Carolina . .	$1\frac{1}{2}$–$1\frac{3}{4}$	90	2	
	West Indies (Others) . . .	$1\frac{1}{2}$–$1\frac{3}{4}$	10	25	
Egyptian (Sakel) . .	Lower Egypt	$1\frac{1}{4}$–$1\frac{5}{8}$	1,100	785	
Egyptian (Uppers) . .	Upper Egypt	$1\frac{1}{8}$–$1\frac{1}{4}$	400	1000	
Pima	Arizona	$1\frac{3}{8}$–$1\frac{5}{8}$	—	4	
Sudan	Tokar, Gezira, and Kassala . .	$1\frac{1}{4}$–$1\frac{1}{2}$	20	140	55
Peruvian	Peru	$1\frac{1}{8}$–$1\frac{3}{8}$	100	220	
Brazilian	Northern Brazil	Up to $1\frac{1}{3}$	100	150	
American (long staple) .	Mississippi, South Carolina, etc. .	$1\frac{3}{16}$–$1\frac{1}{4}$	200	300	
	TOTAL, GRADE 1		2,026	2,628	57—2%
GRADE 2.—MEDIUM					
American . . .	United States	$\frac{7}{8}$–$1\frac{1}{8}$	15,000	13,200[1]	
	Mexico	$\frac{7}{8}$–$1\frac{1}{8}$	150	223	
	Brazil	$\frac{3}{4}$–$1\frac{1}{8}$	300	650	
	Other South American States .	Up to $1\frac{1}{8}$	20	190	
	British East Africa	Up to $1\frac{1}{8}$	50	259	200
	Nigeria	Up to $1\frac{1}{8}$	10	22	22
	Other African Provinces . .	Up to $1\frac{1}{8}$	10	100	
	Australia and Mesopotamia . .	Up to $1\frac{1}{8}$	—	25	25
	India (long staple)	$\frac{7}{8}$–1	300	2,000	2,000
	Russia (long staple)	Up to 1	250	150	
	Others (China, Korea, etc.) . .	Up to 1	100	200	10
	TOTAL, GRADE 2		16,190	17,019	2,257—13%
GRADE 3—SHORT . .					
	India (short staple)	$\frac{3}{8}$–$\frac{3}{4}$	4,000	5,000	5,000
	Japan and Korea		50	147	
	East Indies		70	15	
	Russia (short staple)		750	1,900	
	China		2,000	2,600	
	Persia		130	100	
	Europe and Asia Minor . . .		150	83	10
	TOTAL GRADE 3		7,150	9,845	5,010—51%
	GRAND TOTAL		25,366	29,492	7,324—25%

[1] Excluding linters

THE WORLD'S COTTON CROPS, 1902–1933

Bales of 478 lb. net. 000's omitted. Linters included in American Crop

	America	% of World's Total	India[1]	Egypt	Russia	China	Others	Total	% on 1914
1902–03 .	10,784	61	3,367	1,168	342	1,200	801	17,662	63
1903–04 .	10,016	59	3,161	1,302	477	1,200	751	16,907	61
1904–05 .	13,697	66	3,791	1,263	536	756	803	20,846	75
1905–06 .	10,726	61	3,416	1,192	604	788	938	17,664	63
1906–07 .	13,305	60	4,934	1,390	759	806	1,027	22,221	80
1907–08 .	11,326	62	3,122	1,447	664	875	950	18,384	66
1908–09 .	13,432	61	3,692	1,150	698	1,933	971	21,876	78
1909–10 .	10,386	51	4,719	1,000	685	2,531	950	20,271	73
1910–11 .	11,966	53	3,889	1,515	895	3,467	968	22,700	81
1911–12 .	16,109	61	3,262	1,485	875	3,437	1,058	26,226	94
1912–13 .	14,091	58	4,421	1,507	870	2,360	1,160	24,409	88
1913–14 .	14,614	57	5,066	1,537	969	1,963	1,287	25,436	91
Pre-War	averages	59							76
1914–15 .	16,738	60	5,209	1,298	1,152	2,332	1,154	27,883	100
1915–16 .	12,013	57	3,738	961	1,413	2,068	984	21,177	76
1916–17 .	12,664	58	4,489	1,022	1,085	1,569	1,027	21,856	78
1917–18 .	11,533	63	3,068	1,262	605	865	1,049	18,382	66
1918–19 .	12,146	65	2,937	964	575	940	1,196	18,758	67
1919–20 .	11,486	57	4,476	1,114	440	1,150	1,370	20,036	72
1920–21 .	13,664	68	3,250	1,196	58	955	1,072	20,195	72
1921–22 .	8,285	55	3,668	1,059	43	1,056	1,052	15,163	54
1922–23 .	10,124	56	4,240	1,143	55	1,342	1,269	18,173	65
1923–24 .	10,330	54	4,282	1,309	260	1,453	1,453	19,087	68
1924–25 .	14,006	58	4,736	1,459	521	1,458	1,930	24,110	86
1925–26 .	16,181	61	4,578	1,711	737	1,408	1,965	26,580	95
1926–27 .	18,162	65	4,002	1,628	738	1,418	1,856	27,804	100
1927–28 .	12,957	55	4,489	1,242	983	1,841	1,795	23,307	84
1928–29 .	14,555	57	4,719	1,649	1,208	1,542	1,997	25,670	92
1929–30 .	14,716	55	4,978	1,742	1,351	1,835	1,975	26,597	95
1930–31 .	13,873	55	4,585	1,693	1,589	1,603	1,847	25,190	90
1931–32 .	16,877	64	3,334	1,307	1,851	1,106	2,060	26,535	95
1932–33 .	12,961	55	4,109	1,038	1,778	1,871	1,748	23,505	84
1933–34 . (estimated)	12,968	52	4,320	1,784	1,964	1,950	2,148	25,134	90
Post-War	averages	58							80

[1] These are the Government estimates, which are generally understated. On the other hand, Indian bales are only 400 lb. weight. Taking the Government figures as 500 lb. bales, as is done here, probably offsets the under-estimation fairly well on the whole, though roughly.

trade—the Chinese crop—is probably, on the whole, of Indian quality.

The available statistics with regard to the average supply of these different grades of cotton are summarized in the table on page 29, which also indicates how much of the supply is produced in the British Empire.

The British Empire's share in the world's cotton supply tends to increase yearly. The following table supplied by

the Empire Cotton Growing Corporation gives the figures for 1932, which is an increase of 26·8 per cent over 1931, nearly 100 per cent over 1924, and 400 per cent over 1922 (excluding India).

Anglo-Egyptian Sudan	187,951	
Uganda	162,612	
Kenya	1,408	
Tanganyika	13,200	
Nyasaland	4,054	
Rhodesia	463	
Union of South Africa and Swaziland	2,241	
Nigeria	5,014	
Gold Coast	210	
Cyprus	955	
Malta	33	
Iraq	327	
Ceylon	42	
Queensland	3,980	
Fiji	72	
West Indies	2,019	
	384,581	bales of 500 lb.

The Indian crop for 1932 was 3,615,000 bales of 500 lb. This gives a total of 3,999,581 bales of British Empire cotton grown in 1932, and this will be greatly exceeded for the season 1934 by at least one million bales.

Lower and Upper Egyptian crops are not included, as they are not British Empire production.

Principal Cotton-producing Countries

The following brief notes on the principal cotton-producing countries are arranged in geographical order—

America : The United States.

As will be seen from the table on page 30 the American crop still forms more than half of the world's cotton supplies. The area of the American Cotton Belt, as it is called, is enormous—about 700,000 square miles, or nearly six times the total area of the United Kingdom. It extends into 19 out of the 49 states of the Union, but only 13 produce more than 100,000 bales per annum.

Of the total area of the Belt, only about one-tenth part is under cotton, the record figures in 1925 being 46,448,000 acres (1933–34, about 38,000,000 acres).

The Belt may be divided into three main areas: the Eastern or Atlantic States; the Gulf States, with Texas (which is almost large enough to be regarded as a separate area); and the Mississippi Valley. In addition to these main divisions, there are several districts of which the total area under cotton is still comparatively small, but which promise great developments in the future, namely, the irrigated districts of the Salt River Valley in Arizona, the Imperial Valley in California, and other similar valleys in the West.

Throughout this enormous area the climatic conditions vary considerably. The whole crop, however, with the exception of the small irrigated districts above mentioned, is a rain crop, and the chief variation in the climate of different districts is in the amount of the rainfall. On the Atlantic seaboard it is very heavy. In the Central States the rainfall is less, but the Mississippi and its various tributaries provide ample moisture, and frequently cause disastrous floods. In Texas, again, certain parts of the State are liable to occasional severe drought, which may seriously reduce the yield of a year's crop. A considerable rainfall is, therefore, required in winter to put a good season into the ground as it is called (i.e. to provide a good supply of subsoil moisture against the summer scarcity). The spring rains, which are necessary for planting in all States, may, if excessive, have the effect of hardening the surface of the ground so that the seedlings cannot break through, and thus necessitate re-sowing. Again, in summer, the crop is at the mercy of the weather, too much precipitation being as harmful, and about as likely in certain districts, as the opposite extreme of drought in others. Fine weather in autumn is essential to the proper maturing of the crop, and during the picking season it is still liable to damage by rain, which throws up mud into the low-growing open bolls, thus lowering the

grade or quality of the cotton. As, owing to the lack of labour, the picking season is sometimes very long drawn out, much of the crop may suffer such "winter damage" through being left on the plants half through the winter. Finally, the ultimate out-turn of the crop depends on the date of the first killing frost, which stops growth and kills the "top crop," or late maturing bolls, on the upper branches of the plant. On the other hand, winter frosts and summer droughts serve a useful purpose by keeping down the numbers of the boll weevil, which does so much damage in nearly all parts of the Belt now, except the most northern and western fringes.

The distribution of the different varieties throughout the Belt may be indicated as follows. The best Sea Island cotton (see Fig. 5, on page 26), which was grown on only a few small islands lying off the coast of South Carolina opposite Charleston, has already been referred to. Next to this came Florida and Georgia Sea Island cotton, grown from Island seed in certain portions of South Carolina and Georgia, near, but not on, the coast, and in Florida. As already explained, however, these fine cottons have now practically disappeared before the ravages of the boll weevil. Long staple Upland cotton, sometimes called "Benders," the best of which was little below the second-grade Sea Islands, was grown in the so-called Mississippi Delta (which is really the delta of the Yazoo River and the Mississippi), about 250 miles from the mouth of the latter. This also, however, proved an easy prey to the boll weevil, and is now almost extinct, having been replaced by improved varieties of Upland cotton of about $1\frac{1}{4}$ in. staple.

The great bulk of the crop is the ordinary Upland cotton, which is spread over the whole Belt, but there are many different grades or varieties included in this class, from the real Uplands (so called originally from the fact that they were grown in the Uplands of the Atlantic States) to Orleans and Texas, which are superior grades. Uplands are also sometimes called Bowed

Georgias, from the peculiar form of gin, like a bow string, upon which they were formerly ginned, and which still survives in the East. Finally, the new Western districts of Arizona and California produce some very fine Egyptian cotton as well as ordinary American.

The methods of growing and handling the crop vary considerably in different districts, but the following description may be taken as applying generally to the ordinary Upland crop throughout the Belt. The dates of sowing and picking are naturally the most variable factors, but, generally speaking, sowing begins as soon as possible after the danger of frost is safely past. This means as early as the end of February or beginning of March in South Texas, and as late as the third week in May in the high-lying parts of the Atlantic States. Preparation of the ground is done in spring rather than in the preceding autumn. Deep ploughing is very little practised owing to lack of labour; and, in many cases, ploughing, so-called, is confined to turning over the ridge of the previous year's crop into the adjoining furrow, so that the plants occupy alternate lines in successive years, for in many cases cotton is planted year after year in the same field. The distance between rows is supposed to correspond roughly with the expected height of the plant, say 4 to 6 ft., but the former distance is probably more common than the latter. "Chopping" or thinning out begins about two to four weeks after sowing, when the plant is about 5 in. high, and a distance of 12 to 14 in. is left between the plants. Cultivation begins soon afterwards, and goes on at intervals of about three weeks until July or August. Its object is to remove weeds, especially grasses, for the cotton crop must be kept particularly free of weeds, and to keep the surface of the ground well broken so as to minimize evaporation. It is generally done by special machines called cultivators, which work along the rows between the plants, for which purpose the rows must be wide enough apart to allow a horse to pass between. Hoeing between plants is also

scarcity of labour (and its consequent high cost) and the depredations of the boll weevil. Cotton is a crop which requires, at certain seasons, highly intensive cultivation, and labour must be plentiful and reasonably cheap to make its cultivation in the best way feasible. But labour was both scarce and dear in most parts of the United States; in Texas, in 1913, day wages were as high as a dollar or a dollar and a half per day, while the pickers received from 70 cents to a dollar per 100 lb. of seed cotton picked. As the ginning out-turn is about one-third, this meant that the actual cost merely of picking the cotton was not less than 2 cents per lb. of lint. The prices of everything the planter requires, such as mules, farm implements, fertilizers, and feeding-stuffs of all kinds, had also gone up to an extraordinary extent even before the War, with the result that the cost of production of cotton was probably not less than 12 cents per lb. in Texas. It is very difficult to give a comparable figure for the present day, but it is probable that in 1933 there were important districts in the Belt where the cost of production was as high as 25 cents per lb. owing to the reduced yield per acre due to boll weevil.

The advance of the boll weevil year by year has done much to make cotton-growing less profitable than it ought to be. This notorious pest first appeared in Mexico in 1862, crossed into Texas in 1892, and has since been spreading rapidly throughout the Belt, covering new ground almost every year. The years 1918–20 marked a record advance, especially in the Atlantic States, where its further progress, owing to the peculiarly favourable character of the climate and the vegetation, was more rapid than ever. Its worst damage was in the Sea Island districts, for the conditions which suit the boll weevil best are a moist, warm climate with little frost, and ample vegetation in which it can shelter during the winter. At the same time, it does its worst damage to late maturing cotton, such as Sea Island, and there was, therefore, no hope of saving the Sea Island crop when the boll

weevil appeared in the district. Sea Island was a difficult and expensive crop to grow, and it did not take much to make the growers turn over completely to short staple cotton.

The years 1921 to 1923 produced a feeling almost of despair in the cotton world. It looked as if the boll weevil had so completely changed the whole situation that cotton-growing would never again be profitable in many parts of the American Belt, and that America could no longer be relied upon to meet the major part of the world's demand as it began to recover after the War. In 1924, however, the crop had better luck. High prices had led to a steady increase of the acreage, which was touching new record figures every year; and in 1924 a peculiar combination of circumstances, particularly a long drought, which greatly reduced the numbers of the weevil, but broke just in time to save the crop, and which was followed by a long open fall with hardly any rain or frost, produced a better yield to the acre than any crop since 1920, and (as the result of the record acreage) a crop only exceeded by those of 1911, 1913, and 1914. Whether this was merely a casual combination of favourable circumstances and not likely to be repeated, or whether the boll weevil had really suffered a permanent check, it is too soon yet to say.

During the past few years it appears that this boll weevil menace has been somewhat subdued, as the yield per acre indicates, viz.—

1928 yield per acre	. 161·7 lb.	
1929 ,, ,, ,,	. 163·3 ,,	
1930 ,, ,, ,,	. 164·1 ,,	
1931 ,, ,, ,,	. 157·0 ,,	
1932 ,, ,, ,,	. 211·5 ,,	
1933 ,, ,, ,,	. 173·3 ,,	
1934 ,, ,, ,,	. 209·4 ,,	(estimated)

The West Indies.

Now that the American supply of Sea Island is lost through the advance of the boll weevil, the only alternative supply of the finest cotton is in the West Indies.

There, thanks largely to the assistance of the British Cotton-Growing Association, the islands—many of which were threatened, thirty-five years ago, with economic ruin through the failure of other crops, such as sugar—were rescued and made prosperous again by the reintroduction of the cotton plant from the Sea Island districts. The conditions in the West Indies are in many ways similar to those of the Carolina Islands; and while space will not allow of any detailed description of the various islands or their different conditions, the following summary of the resulting crop may be given. Of the pre-War total of, say, 7,500 bales of Sea Island quality about 1,500 were equal to the best or "Crop lots" of Island cotton, which before the War fetched as high as 40d. per lb. in Liverpool. They were grown chiefly in St. Vincent, St. Kitts, and Barbados. Of the remainder, about 4,000 bales were considered equal to Graded Island cotton, and the remaining 2,000 to Floridas and Georgias. There was also a quantity of lower grade cotton, known as Marie Galante, a wild type of native cotton, believed to be related to the true Sea Island, but of inferior staple, which amounted to well over 1,000 bales. In Hayti there was a large crop, amounting apparently to about 10,000 bales, of a still lower type, which, however, was not usually counted in the West Indian crop at all.

During the War, however, owing to the abnormal price of sugar, the cotton crop of the West Indies had again to face serious competition from the rival crop, and from this it has never fully recovered, the total crop in 1924 being probably about 4,000 bales. This competition was accentuated at times by the very low premium obtainable for long staple cottons. The crop in 1933–34 was only 2,000 bales.

Mexico.

Mexico is typical of the Spanish and other colonies in Central and South America, countries of great possibilities for cotton-growing, but with very poor performance.

There is no doubt that an enormous crop could be produced in Mexico, partly under irrigation, for which there is ample water supply that could be developed; but there is no prospect at all of this being done for some time to come, owing to the very unsettled state of the country both economically and politically.

Brazil.

Cotton has been cultivated in Brazil probably from time immemorial, and was found growing there by the Portuguese in 1500. It was first introduced into England in 1781, and was our chief source of supply till 1800. At one time great quantities were exported; but during recent years many mills have been erected in the country, and probably the greater part of the crop is now consumed there. There is no doubt that the possibilities of the country for cotton-growing are immense, but all the necessary conditions seem to be lacking, viz. energy, capital, and labour. The reported yields per acre are almost the highest in the world, and probably exceed even those of Egypt. The cotton area is large, and is spread over a very large part of the country. The names of many of the provinces and some towns in the cotton-growing districts are found in those of the types of cotton named in the Liverpool list, such as Pernambuco, Parahyba, Rio Grande do Norte, Maceio, Mossoro, and Ceara. In these different provinces the conditions of cotton-growing vary considerably.

Two different varieties of cotton seem to be chiefly grown, and these are of radically different type. The one is a tree cotton, known as Creoulo or Maranhao cotton, which yields well for several years and bears open bolls almost all the year round. The lint of this tree cotton is of very good quality and length, and the plant is drought-resisting and appears to enjoy a remarkable immunity from insect pests, in marked contrast to all other tree cottons throughout the world. The other is the ordinary, short-stapled, herbaceous cotton, and is

chiefly grown in the coastal districts where the rainfall is more reliable. The lint from these two species varies greatly in length, from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in., but the average is about 1 in. to $1\frac{1}{4}$ in. The careless mixture of different staples is almost universal. The general character of Brazilian cotton is good; it possesses a peculiar harsh or wiry character, which makes it specially suitable for mixing with wool. It is generally badly handled in picking and ginning, only saw gins being used.

Peru.

The conditions here are markedly different from those above described, and, indeed, Peru may be regarded as the exception to the rule of the unsatisfactory conditions of cotton-growing in Latin-America. Cotton is grown entirely under irrigation, as the climate is practically rainless; but the water supply from the rivers—snow-fed from the mountains in summer—is ample, and only the lack of funds for irrigation works seems to stand in the way of large developments of cotton-growing. The climate is favourable, being free from violent extremes of heat or cold; while transport facilities by the rivers are naturally good, and have been augmented by railways.

The varieties grown are chiefly two, known respectively as Smooth Peruvian and Rough Peruvian, the former being in pre-War days about 65 and the latter 30 per cent of the total crop. The former is usually grown as a biennial, while the latter is perennial. A small quantity of Sea Island is also grown, though of rather inferior quality; and in recent years an increasing quantity of Egyptian cotton has been grown from imported seed.

There has also appeared since about 1918 a new, smooth, white variety, known as Tanguis, of doubtful origin, which proved very useful as a substitute for the better varieties of Upland cotton during the scarcity of 1922–24, and which has largely replaced the smooth and Egyptian types.

In the southern part of the American Continent, especially in the Argentine, there are enormous areas which might produce large crops of cotton, and many successful experiments have been made, but the difficulty of the labour supply seems to prevent the development on a large commercial scale of a crop which requires so much labour for its cultivation.

Africa : Egypt.

The outstanding characteristic of the Egyptian crop is that it is entirely grown under irrigation, Egypt being practically rainless, except for a slight winter rainfall along the northern coast. Thanks largely to the excellent regulation of the water supply to the plant which is thus rendered possible, also to the magnificent deltaic soil of which the whole country is composed, and the generally favourable and dependable climate, the Egyptian staple is the second best in the world, and the whole conditions of the crop were, on the whole, the most satisfactory of any country till about 1909. The yield was extraordinarily high; it had exceeded in the past 500 lb. of lint per acre, and the whole methods of cultivating and handling the crop were until recently a model to the cotton-growing world.

This was largely due to the fact that the labour supply was ample and in its own way exceedingly good; while the commercial handling of the crop from the field to the ship's side was in the hands of a small number of large European firms, who saw to it that the crop was picked, ginned, baled, compressed, and exported in the best possible condition, with the result that the Egyptian bale was one of the best in the world.

The chief varieties now grown have already been mentioned. The latest, Sakel, rapidly took the place of the former most common variety in Lower Egypt, namely, Afifi or Brown Egyptian; but it has for some time shown signs of going the same way as all its predecessors—deterioration in quality—and in 1924 large quantities

of Ashmouni or Upper Egyptian cotton and other short-stapled varieties were grown, even in the Delta.

The prospects of the Egyptian crop were, until 1909, exceedingly bright, and the crop was making steady progress in quantity, but this has, unfortunately, been very seriously checked during the last few years, partly owing to a new insect pest, the pink boll worm. Great schemes of drainage, irrigation, and reclamation were on foot which would have resulted in a considerable increase of the crop, but these were suspended on the outbreak of the War, and have not yet been taken up again to the original extent. Until 1925 there was little hope of the Egyptian crop's touching its 1913 record again, for, although the acreage had again established new records, the average yield per acre had fallen far below the records of pre-War days; 1933–4, however, slightly exceeded the record of 1913.

Sudan.

In the Sudan there are enormous prospects of development, especially in the Gezira district between the Blue and White Niles; but, in addition to the expenditure required on irrigation works, the development of this area depends upon the replacement of the population destroyed by the wars of 1883–98, and this takes time. The Tokar area on the Red Sea coast is doing very well, and has been greatly improved by expenditure on railway and irrigation works.

But the chief hope of the Sudan lies in the Gezira plain, where 300,000 acres are now in cultivation under irrigation from the new dam at Makwar on the Blue Nile, completed in 1924–25, and it is believed that a still larger area can be covered by the available water supply. At Kassala there is another new area irrigated by the River Gash, and there are also great possibilities of rain-grown cotton in the Southern Sudan.

In 1932 188,000 bales were produced, and this may be exceeded in 1933–34.

East Africa.

In Uganda, again, there are great possibilities, but the difficulties of communication and labour supply, which are the great stumbling blocks to the development of all our interior African colonies, prevented any really great development there till after the War. The largest crop yet reported was that of 170,000 bales in 1924, and there is hope of that figure being doubled in the near future. Similar difficulties are delaying progress in Nyasaland, where there can be no question of the possibilities of the country, but much will require to be done in the way of improving railway and river communications before the present crop of less than 10,000 bales per annum can be materially increased.

There are also good prospects in Tanganyika (formerly German East Africa). In 1932 the crop was over 13,000 bales of 500 lb. each.

West Africa.

The magnificent pioneer work of the British Cotton Growing Association in West Africa, as well as in the other African colonies already mentioned, has proved the possibilities of the country beyond doubt. But the provision of communications and the gradual opening up of the country will require a great deal of time and money, and the rapidity of progress has hitherto been checked by the fact that the local variety of cotton was just not quite good enough to make a really conclusive comparison from the point of view of the grower's profit with other competing crops, which have the great advantage of requiring less care and labour for their cultivation. Since the War, however, the situation seems to have changed very markedly in Northern Nigeria owing to the introduction of an American variety, which gives a much better return because of its higher yield and ginning out-turn and better quality. The area available in Northern Nigeria is immense, and it may be hoped, now

that the corner has apparently been turned, that future development will be much more rapid.

India.

India suffers sadly from her evil reputation in the matter of cotton-growing. As a matter of fact, India to-day is growing from 1,500,000 to 2,000,000 bales of cotton, similar to American in quality and of nearly an inch in staple, sometimes more, which is quite fit to be used in Lancashire, and which is, as a matter of fact, very largely used both in India and in Japan at the present time in place of American. It was largely the question of the condition of Indian cotton that told so strongly against it in English markets. But the inferiority of the staple is a more serious matter. The ancient tradition of the Dacca muslins is to the effect that cotton as fine as 300's was habitually produced in India long ago. Even allowing for the exaggeration of tradition, it is difficult to reconcile this statement with the fact that the bulk of the Indian crop to-day is of only about $\frac{3}{8}$ in. to $\frac{5}{8}$ in. staple.

The Indian cotton area is immense and very widely scattered; in 1930 it was over 26,500,000 acres, and there is still room in the future for a considerable increase (e.g. as the result of irrigation schemes in the Punjab and Sind, and also by the gradual substitution of cotton for other crops). But the essential condition of that substitution is that the native cultivator must be convinced that cotton will pay him better than these other crops, which is doubtful, unless at high prices. This is due to many causes, of which the principal are the very low yield and the very poor quality of his cotton. In the former lies the real hope of a substantial increase of the Indian crop. The average yield over all India is only about 80 lb. per acre, as against about 200 in America and 350 in Egypt. The average in India could be materially increased in various ways, all of which would also tend to improve the quality and therefore the value of the crop. The chief are seed selection and improved

methods of cultivation. In both these matters a great deal has already been done by the Government Agricultural Departments; but it is admitted that something more is required. Up till 1914 the policy of the Government had always been to demonstrate to the natives the possibilities of improvement, and to offer them facilities such as better seed, improved implements, etc., but never to *compel* any alteration in their present methods.

The methods of handling the Indian crop before the War required drastic amendment. The system of small ginneries, which was prevalent almost everywhere, owned by natives who acted as merchants, buying the crop locally and re-selling to the larger firms in the exporting centres, was bad; and there was a growing conviction that the Government would require to interfere by introducing a system of licensing and control of the ginneries to prevent damping, fraudulent mixing, and the careless ginning and handling of the crop. The Government could then have done a great deal more in the way of seed supply than it had hitherto attempted, particularly by showing on a large scale, by a model seed farm and plantation, how good cotton can be grown and handled and disposed of in India. Certain districts have done a good deal already in the way of seed supply, and in the direction of assisting the growers to find the best market for their crop, for one of the greatest difficulties of the improvement of the crop is that of securing adequate remuneration for the cultivator who tries to improve his crop by using good seed.

In so large an area, extending over nearly 30 degrees of latitude from Peshawar to Tinnevelly, the variations of climate are enormous, and at certain seasons of the year cotton is being both sown and harvested in different parts of India at the same time. Local conditions of soil and climate also vary greatly even between districts quite near each other, so that the variety of cotton best suited to one district may be quite unsuitable to another. The best varieties are grown in Madras, and in the Broach and

Surat districts of Bombay Presidency. Cotton of American type is grown in Southern Madras (e.g. Cambodia), and in Dharwar (South Bombay), and the Punjab. On the whole, cotton is a "monsoon" or rain-grown crop throughout India; but in the Punjab irrigation is almost universal, the rainfall being quite insufficient, and in practically all provinces the rainfall is supplemented by well irrigation.

The methods of cultivation are, on the whole, very primitive. Fertilizers, for example, are little used, and the introduction of improved agricultural implements, even of the simplest kind, is necessarily slow, though the Departments of Agriculture have done excellent work in this direction. Co-operative methods have proved successful in certain districts, but the difficulties of making any radical change in general methods throughout a country so large and so conservative as India are enormous.

Since the War, however, largely as the result of reforms recommended by the Indian Cotton Committee of 1917–18, progress in India has been much more rapid. A permanent committee, known as the Indian Central Cotton Committee, now interests itself in everything connected with cotton-growing, supported by the Government and a cess of four annas per bale on the Indian crop. Measures are under way for control of the ginneries, and the hands of the Departments of Agriculture have been greatly strengthened in such matters as seed selection and distribution.

Russia and China.

The only other areas that remain to be mentioned are Russia and China. In Russian Turkestan, and in the region between the Black Sea and the Caspian, Russia possesses a most promising area for cotton-growing, which was already giving a crop of well over a million bales before the War. The conditions are more similar to those of Egypt than of any other country, as cotton is largely grown under irrigation. The staple was good,

much of it being about the quality and length of American, though the native varieties, which are still grown in considerable quantities in certain parts of the area, are similar to the short staple Indian varieties. The prospects of development were very good, and at first it appeared that the Russian crop, alone throughout the world, was making rapid strides during the War. Report gave the crop as 1,500,000 bales in 1916. But the War and the Revolution played sad havoc with this promising field, which was entirely dependent on other parts of Russia, especially for its food supply. The economic upheaval, therefore, practically destroyed the crop, and in 1925 it was only painfully returning to a possible production of one-half of the record figures. The latest report gives the crop as 1,960,000 bales in 1933.

China is the unknown quantity in the world's cotton supply. Her crop is certainly large, but the very high figures which were semi-officially circulated a few years ago, giving totals as high as 5,000,000 bales, are now generally reduced to about 2,000,000 bales. The area under cotton seems to be widely distributed over many parts of the country, and is still capable of large extension. Probably the greater part of the crop is used for domestic consumption in the wadding of garments and domestic spinning; but a considerable amount is exported to Japan, and a good deal is now being used in local factories in China, which have been developing rapidly in recent years. The quality of the staple is mostly short, more like Indian than anything else, but efforts have been made, with marked success, to introduce American varieties, which seem to do well. The same applies to Korea, in which Japan is fast developing a promising source of supply for her own mills. The crop in Japan itself is very small and apparently dwindling in amount.

The British Cotton Growing Association.

No description of the world's cotton supplies would be complete without a reference to the work of the British

Cotton Growing Association. In the closing years of the nineteenth century the situation with regard to the supply of cotton had begun to give rise to considerable anxiety. Already in 1900 the Germans had begun to develop cotton-growing in their African colonies. The first step which led to the formation of the British Cotton Growing Association was taken by the Chamber of Commerce at Oldham in January, 1901, when a committee was appointed to make inquiry into the possibilities of growing American cotton in other countries, and particularly within the British Empire. The committee's report, published in November, 1901, was favourable; and on 18th February, 1902, the matter was further discussed at a representative meeting held at the Manchester Chamber of Commerce, when an influential committee was appointed. In the meantime, the late Sir Alfred L. Jones had taken up the matter on his own account and, in May, 1901, had sent out 10 tons of American seed to the West African colonies. On 7th May, 1902, Mr. J. Arthur Hutton, Acting Chairman of the West African Committee of the Manchester Chamber of Commerce, invited Sir Alfred Jones and some of the leading West African merchants to dinner at the Albion Hotel, Manchester, and at that dinner the British Cotton Growing Association was born. At a general meeting of the various associations and other bodies interested, held at the Manchester Chamber of Commerce on 12th June, 1902, the Association was formally inaugurated, Sir Alfred Jones being elected President, and it was decided to raise a guarantee fund of £50,000. A fair response was made to the appeal for funds, considerable subscriptions being received from the organizations representing the cotton operatives, as well as from the employers.

The Oldham Committee had already, through the Colonial Office, instituted inquiries into the possibilities of cotton-growing in our various colonies, and these were now followed up by sending consignments of seed and

machinery to various countries which had been pointed out as suitable for experiment, and by grants to planters and others, while experts were sent out to various parts of the British Empire to inquire into their possibilities. The results were so satisfactory that, in November, 1903, it was decided to increase the guarantee fund to £100,000. At this stage the matter suddenly acquired increased importance from the peculiar conditions of the cotton market, due to Sully's "corner," the price of Middling rising from 5¾d. in November to nearly 9d. in January, 1904. Under these circumstances the Association decided to increase its capital to £500,000. In the King's Speech at the opening of Parliament, on 2nd February, 1904, the situation was referred to in the following passage: "The insufficiency of the supply of the raw material upon which the cotton industry of this country depends, has inspired me with great concern. I trust that the efforts which are being made in the various parts of my Empire to increase the area under cultivation may be attended with a large measure of success"; and the interest thus shown in the matter in high quarters was further proved by the grant of a Royal Charter to the Association on 27th August, 1904. It only remains to add that of the capital of £500,000 all but a few thousands has now been raised.

The Association in its early years did good work in calling the attention of the Indian Government to the possibilities of the development of the Indian crop, and a model plantation is now operated in the Punjab. Its work in East and West Africa has already been referred to, and the development of the Sea Island crop of the West Indies has been largely due to the Association. It has also given valuable assistance in the encouragement and development of cotton-growing in areas already established, such as Egypt and the Sudan, and, since the War, also in Iraq and Australia. The experience of the Association has proved that the best policy to adopt in dealing with native cotton growers is to encourage

them to become independent cultivators of their own land, rather than to attempt large plantations under European management with the natives as paid labourers.

In addition to the experimental work and educational propaganda, the work of the Association has been to provide and maintain modern ginneries in different areas; to establish, where possible, a buying system at a fixed price, which would secure to the grower a reasonable and safe remuneration; and to stimulate the various governments in providing railway and other transport facilities—for the difficulty of transport has so far been, and will probably continue for many years to be, the limiting factor in the development of cotton-growing in new countries, especially in Africa.

Another hopeful factor in the cotton situation since the War is the establishment of the Empire Cotton Growing Corporation, set up in 1920 as the result of the report of the Empire Cotton Growing Committee of the Board of Trade. The new corporation received a Government grant of about a million sterling and a contribution from the cotton industry of 6d. a bale. This has enabled the Corporation not only to give valuable assistance in co-ordinating the scientific and agricultural development work which is being done in cotton in all parts of the Empire, but also to render direct assistance, especially in the provision of expert staffs in many of the new fields throughout the Empire. The Corporation publishes quarterly the *Empire Cotton Growing Review*.

New Strains of Empire Cotton.

The greatest developments in the production of new strains of cotton appear to have been arrived at in Egypt, which country has always been noted for the good quality of its cotton. Here, three new strains have been produced, Maarad, Giza 7, and Sakha 4. Maarad is the longest fine-staple cotton produced in Egypt, and is also the best yielding. Spinners like it because it has a good staple, and is fine, long, very regular, of excellent appearance,

and of a light-brown colour. It is now preferred by growers because, when compared with Sakel, it suffers less from the pink boll-worm, and gives a cleaner cotton and better ginning returns.

Giza 7 type originated from a single plant selection in 1922, and in 1926 one-fifth of an acre was sown with it. Its yield is superior to Sakel, but in grade is slightly inferior. Its production has rapidly increased from 2,800 bales of 775 lb. in 1930 to about 30,000 bales in 1933. This variety is a high-yielding one, and is popular with spinners because it is a comparatively cheap substitute for Sakel.

The Botanical Section of the Ministry of Agriculture, Egypt, selected a strain of cotton in 1927 known as Sakha 4. It has a long staple and resists wilt in fields that are severely infected. Certain immune strains have been selected, and in 1933 220 acres were sown. Great results are expected in 1934.

CHAPTER III

THE SPINNING MILL

Defects in Cotton.

IT is extremely important in proceeding with the manufacture of cotton cloths that a thorough knowledge should be gained of defects found in cotton. The following are some of the principal: variation in length of staple; variation in diameter of fibre; weak fibres; rough, harsh, intractable staple; bad colour; insufficient lustre or bloom; large percentage of sand, dirt, leaf, shell, seeds, small pieces of broken seeds with fibre attached to them, called "bearded motes," neps, dead and unripe fibres, also fibres with few helical twistings owing to the cotton being grown under bad conditions. All the above defects have a deteriorating effect upon the value of cotton.

There are other defects that lower the value of raw cotton, and should be carefully noted. Where bales are left uncovered and exposed to the weather, as seen in Fig. 7, left on muddy ground, or packed in dirty wagons, they are liable to get stained, damp, or dirty during transit from the ginnery to the shipping port, and are then known as "country damaged." This damaged cotton is picked off, thus reducing the weight of the bale.

Every bale of cotton has a mark painted on, and this mark is a distinguishing feature of the bale. If the mark has been removed, as in the case of country damaged cotton, then it is known as "no mark" cotton.

The longer the staple, providing the fibres are regular in length, the finer the fibre with the least percentage of the above defects, and the higher the price of the cotton.

Boll-stained or tinged cotton, sun-dried cotton, also staples which have been damaged by frost, insects, etc., have a lower value.

There are many features in cotton that are looked for

when a spinner intends to buy, such as good colour, bloom, regularity of staple, cleanliness, etc. Cotton which is neither too white nor too creamy is termed of "good colour."

A serious defect in cotton is the presence of immature

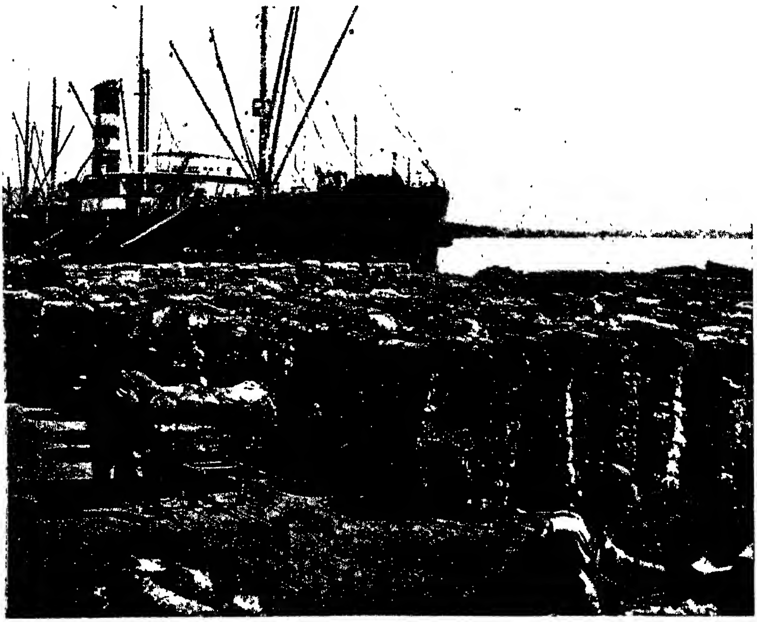


FIG. 7. SHIPPING COTTON AT NEW ORLEANS

fibre, as this "mossy" cotton causes much trouble both in spinning and finishing.

Testing Cotton.

The strength of individual fibres varies considerably; some fibres have a breaking strain of 46 grains only, whilst others will bear 212 grains before breaking. From this statement it will be seen that only a small percentage of the actual strength of the fibres in any cross-section of yarn is utilized in offering the resistance to breakage,

so that much depends upon the twisting together of the fibres so as to prevent actual sliding of fibres over each other when a thread breaks.

The testing of cotton fibres is often done by pulling out a small tuft or staple by the fingers, which indicates the length and fineness of the fibres. When this test is applied the cotton should have a "pull" with it when drawing the fibres away from their fellows. The strength is tested by snapping or breaking the tuft. Note is also taken of the nature and amount of the impurities present; also the amount of short fibre and waste.

Microscopical tests are useful in comparing the relative spinning qualities of cotton, as it can then be seen whether the fibre possesses many helical twistings or not, and whether the fibres are dead, undeveloped, or unripe, owing to being grown under unfavourable conditions. These fine tests are most useful, because, in order to spin a good warp yarn, the fibres must be fully matured, that is, having the helical twists and thickened edges. These characteristics cause the fibres to cling together when spun into yarn.

Other tests, such as burning the fibres and threads, are sometimes used to ascertain if yarns contain cotton, wool, or silk. The difference in the smell of these fibres when burning is easily distinguishable. Owing to cotton being a vegetable and wool an animal fibre, it is possible to dissolve the cotton fibres from any woollen yarn or fabric.

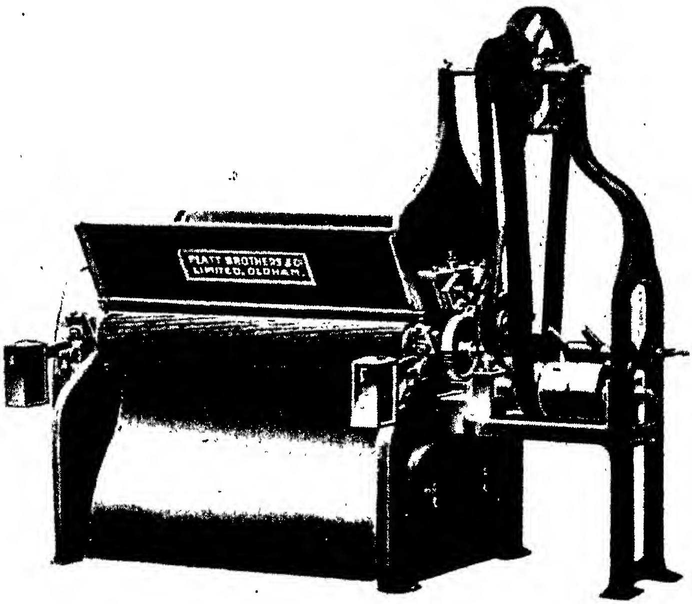
Strong hydrochloric acid completely decomposes cotton, also nitric acid when used as a hot solution. Iodine solution stains cotton blue.

Ginning of Cotton.

The first mechanical process that raw cotton passes through is ginning, that is the separation of the fibre from the seed. This work is carried on in buildings adjacent to the cotton-fields. The perfect gin has not yet been found, perhaps because of the many inequalities there are in the cotton. Fibres break, are torn, or carry with them

small portions of seed, no matter where grown or how careful the operators are when ginning.

Many forms of gins have been invented, but at the present time only two are used to any extent as mentioned in Chapter II, viz. the roller gin, Fig. 8, and the saw gin,



By courtesy of *Messrs. Platt Brothers & Co., Ltd.*

FIG. 8. ROLLER GIN

Fig. 9. The roller gin is adopted in countries other than America, where the saw gin is the most used, although it has very serious faults, the most serious being its rough treatment of the fibres.

Fig. 9 shows one form of the saw gin, the principal feature being the grid *A* and the very finely cut circular saws *B*. There are from 60 to 80 of these saws on a square shaft; they project through the grid *A* against which the seed cotton is thrown, and the revolving saws pull the

fibres through the grid. The grid bars are set close enough together to prevent the seeds passing through, and these fall on to the floor at *M*. The seed cotton from the feed-box *K* is carried by the lattice *H* to the feed roller *J*—the roller *L* prevents overfeeding. The cotton falls into box *G*, where it comes into the path of the saws *B*. Saws *B* pull the fibre from the seeds and carry it upwards, where

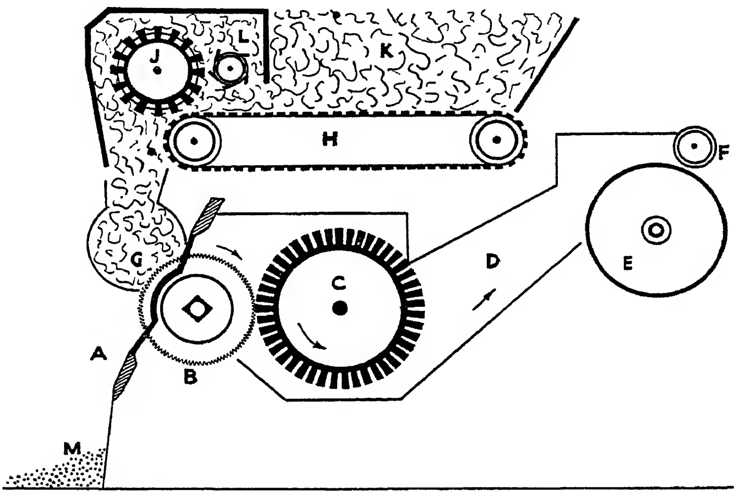


FIG. 9. SAW GIN

the brush *C* removes the lint from the teeth of *B* and drives it along passage *D* to condensing rollers *E* and *F*.

The weight of seed is about twice that of the fibre—from 300 lb. of seed cotton only about 100 lb. of fibre will be obtained.

After being ginned the cotton is compressed into bales for shipment.

Technical Colleges and Societies.

In most of the spinning mills of this kingdom cotton is spun for sale as yarn; in others, owned by manufacturers, twist and weft are produced for consumption in the weaving sheds, the surplus yarn being sold or the

deficiency made up by purchase. Good management is indispensable to success. The sequence of processes down to the minutest details must be perfectly familiar to the manager, who has to be able to so co-ordinate the productive system that the greatest weight of yarn is got off within the hours of running, at the least cost, quality of staple, of course, being a dominating factor. Most of the managers and overlookers of the present day have been trained in the technical colleges which have become part of our educational system.

There are many technical colleges in the manufacturing districts, the most important being Manchester, Blackburn, Preston, Salford, Nelson, Bolton, Oldham, and Burnley, where full textile courses are held for both day and evening students.

During the past few years the technical side of the cotton trade has been greatly advanced by the activities of the textile societies, whose object is to further textile education by means of lectures and discussions. There are 34 such societies in Lancashire and Yorkshire, and all are members of The Federation of Textile Societies, which now represents 12,000 student-members.

Distribution of Spindles.

The erection of a spinning mill is an expensive undertaking, and may be roughly computed to cost about 45s. per mule spindle. The wages of the operatives in the cleaning, carding, and spinning departments are in most cases arranged between the masters' and the workpeople's organizations, and the British cotton operatives are absolutely unrivalled for manual dexterity, intelligence, and efficiency. Localization of particular industries is among the phenomena of British industrial life. For instance, the Manchester and Bolton districts hold the predominance in fine spinning, though the production of fine counts of yarn has somewhat rapidly proceeded of late years in other towns—Oldham, Preston, etc. Oldham and the south-east Lancashire cotton towns are the

greatest industrial areas of England in which American cotton, from which medium counts are spun, is consumed.

The spinning industry is widely spread over Lancashire as shown by the following list—

Oldham and district . .	17,400,000	spindles
Bolton and district . .	7,764,000	,,
Rochdale and district . .	3,797,000	,,
Manchester and district .	3,439,000	,,
Leigh and district . .	3,271,000	,,
Stockport and district . .	2,296,000	,,
Ashton-u-Lyne and district .	1,916,000	,,
Preston and district . .	1,998,000	,,
Farnworth and district. .	1,483,000	,,
Middleton and district . .	1,257,000	,,

and Blackburn, Bury, Heywood, Mossley, Stalybridge, and Wigan have each over one million spindles.

Yarn Conditioning.

Like good fruits, yarns improve with a certain amount of keeping.

Yarn kept for some days in a damp cellar or conditioning room improves in strength and working qualities generally. The natural tendency to snarl is taken out of the yarn, and it is thus rendered easier to handle at the next process. The natural moisture extracted during the opening operations is also returned to the fibres. In yarn, strength, evenness, elasticity, and good colour are essential.

The conditioning of yarn is a very necessary process and quite legitimate. The spinner buys cotton by weight, and the cotton he receives contains $7\frac{3}{4}$ per cent natural moisture of the total weight. During the various processes of spinning much of this moisture is evaporated owing to the heat of the spinning rooms. If the spinner leaves the yarn long enough in a cellar where the temperature and humidity are suitable it will regain all the lost weight, but this is a slow process. To do the work quicker artificial means of adding moisture are used, and this is known as "conditioning."

Special conditioning plants are made and used in

many mills, but the method most generally used is the simple one of placing the skips of yarn in rows on the floor of a cellar. The floor is usually of concrete, and this is covered with bricks placed loosely on their edges. Water is run in until there is sufficient to keep the atmosphere well charged with humidity.

Yarn, of course, will absorb more than the $7\frac{3}{4}$ per cent natural moisture without feeling damp, and, as the yarn is sold by weight, no manufacturer cares to pay the yarn price for excess water; so the deliveries from the spinner are always tested.

Yarn Testing for Moisture.

To test cotton and yarn for moisture it is usual to weigh a small quantity, say, one or two pounds, and dry it in a specially constructed oven until the whole of the moisture has been extracted. It is then weighed, without removal from the oven. An addition of $8\frac{1}{2}$ per cent is then made to the dry weight to obtain the "correct" weight. Any difference between the correct and original weights is considered to be excess moisture.

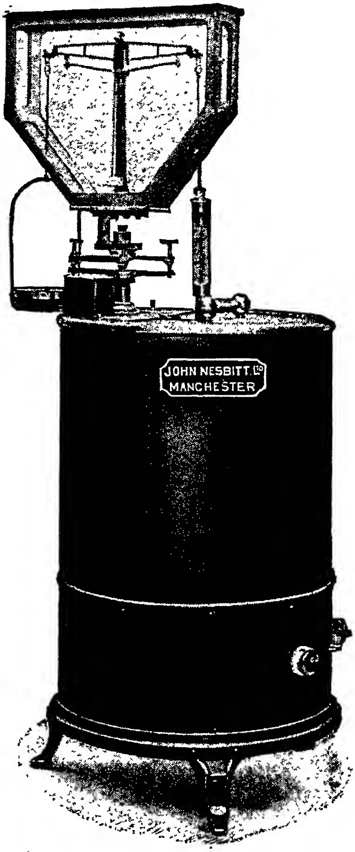
The special oven used for drying yarn and cotton when testing for moisture is shown in Fig. 10. This oven has a base of strong tinned iron mounted on a cast-iron base frame with levelling screws, and contains the two heating elements, which are controlled by separate switches. The drying chamber, of hard-rolled copper with a cast-iron top, is separated from the base by means of a perforated zinc baffle plate, and is entirely lined with asbestos to conserve heat.

The balance is enclosed in a glass case with hinged parts, to provide easy access to all the balance parts. It is mounted on a tripod stand with levelling screws, and is of polished aluminium. It is strongly made and yet very sensitive.

An adjustable thermostat is mounted beneath a strong cover on the lid, and automatically maintains the temperature at any predetermined number of degrees.

The thermometer, which itself supports the sample container, has a long immersion tube, with the bulb so situated that a true reading is obtained of the air actually in contact with the sample under test.

The sample is placed in the container and the heat switched on. As the moisture is evaporated weights are placed in the pan until the beam remains steady, when the weights show the moisture present in the sample.



By courtesy of Messrs. John Nesbitt, Ltd.

FIG. 10. ELECTRICALLY-HEATED CONDITIONING OVEN

Cotton for Warp Yarns.

For "twist" yarns (yarn intended for warp) the spinner uses a better staple than is required for weft yarns, since the twist yarn requires to be level, strong, and compact, so that it can resist the strain of sizing, weaving, and the finishing processes. On the other hand, weft yarns have little strain put upon them, so the shorter staple cottons are used.

Under ordinary conditions the staple lengths required for twist yarns are about the following: up to 16's, $\frac{5}{8}$ in. to $\frac{3}{4}$ in.; 20's, $\frac{7}{8}$ in.; 24's, 1 in.; 30's, $1\frac{1}{16}$ in.; 36's to 42's, $1\frac{1}{8}$ in.; 50's, $1\frac{3}{16}$ in.; and $\frac{1}{16}$ in. on for every 10 counts up to 100's which is $1\frac{1}{2}$ in.

As twist yarns are always sized before weaving, colour is not so important as when the cotton is intended for

weft which is not sized. Sizing itself tends to alter the colour. When the cloth is intended to be bleached then the colour of the cotton does not matter.

Sequence of Operations in Spinning.

The sequence of operations necessary for the conversion of cotton into yarn is as follows—

Bale opener	Opening and cleaning
Mixing	
Hopper feeder or opener	
Scutcher	
Carding engine	Carding
Draw frame	Drafting and doubling
Slubbing frame	Drawing and twisting
Intermediate frame	
Roving frame	
Ring spinning frame or mule	Spinning

The sequence for fine counts or combed yarns is—

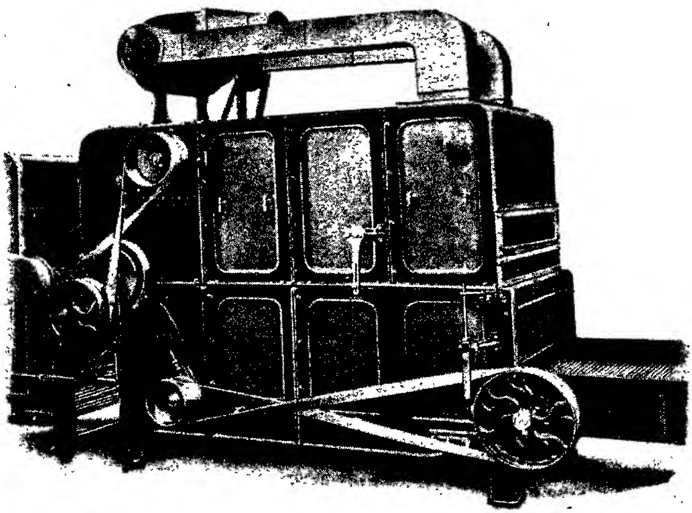
Bale opener	Opening and cleaning
Mixing	
Hopper feeder or opener	
Scutcher	
Carding engine	Carding
Sliver lap machine	Combing
Ribbon lap machine	
Comber	
Draw frame	Drafting and doubling
Slubbing frame	Drawing and twisting
Intermediate frame	
Roving frame	
Second roving frame or Jack frame	
Mule	Spinning

We will assume that cotton has been bought at Liverpool to suit the needs of the spinner, and that the bales are duly delivered at the mill.

Let us proceed to the first treatment of the raw cotton. After it is delivered to the spinning mill the bales are weighed and a few of them opened and examined to see if they are right in quality, according to the sample from which they have been bought. The bales are now taken to the bale breaker or mixing machine.

Bale Breaker or Mixing Machine.

If the cotton is mixed by machine it will be done by the hopper bale breaker. The hopper addition to mixing and opening machinery is one of the greatest improvements made in recent years. The hopper bale breaker (Fig. 11) is very strongly built, and consists of a hopper box, into which the feed lattice drops the cotton.



By courtesy of *Messrs. Platt Brothers & Co., Ltd.*

FIG. 11. HOPPER BALE BREAKER

Or large armfuls may be thrown direct into the hopper box, at the bottom of which is a short floor lattice which delivers the cotton to an inclined spiked lattice moving upwards at about an angle of 35° from a vertical line. The spikes of this lattice take hold of the cotton and carry it upward. Near the top of this lattice is an evening roller, which throws back any large masses. At the rear of the spiked lattice is a stripping roller which clears the lattice, the cotton falling on a short lattice near the bottom of the machine. This carries the cotton to a pair

of inclined or vertical lattices, which press the cotton between them. These lattices carry it upwards and drop it on another lattice, from which, by other lattices and a reversible arrangement, it can be distributed to any part of the mixing room. There may be as many as six mixings in the room.

About 30,000 lb. of cotton can be passed through the bale breaker in one week of 48 hours.

The work of the bale breaker is to open the cotton direct from the bale, clean it of the heaviest dirt by gravity, and assist in mixing or blending the various cottons. The dirt, etc., falls through a grid into a box, which can be removed while the machine is working.

Mixing.

The mixing together of different varieties and staples of cotton is essential in order to get the average quality of the cotton used. Mixing, too, brings about more uniformity in the quality of the yarn. Cotton of long, strong, and cohesive staples is best adapted for twist, and cotton possessing these spinning qualities in a less degree is used for weft.

A twist yarn forms the foundation of the cloth and has to stand the strain put upon it in winding, warping, sizing, and weaving, and on this account it has to be a strong, smooth, cohesive yarn. A weft yarn forms the covering or "filling" for the cloth, and requires to have a soft, silky, oozy feel and appearance. It is not necessary for the weft to be as strong as the twist yarn, because the former is taken direct to the loom and is subjected to very little strain.

There are two ways of mixing: (1) by hand, or (2) by machine. In the latter case a certain amount of cleaning is secured by the action of the machine. In the former there is no cleaning. The advantage of hand-mixing is that the cotton is better blended, and thereby more uniformity in the quality of the yarn is secured, but the cost of production is increased thereby.

To test the quality of a mixing one may take a vertical section of the stack so as to get an even lot. Pass it through every spinning machine in the mill, then test the yarn and compare it with the standard quality generally kept in stock to see that it is up to the required strength, colour, cleanliness, counts, etc.

The usual method of mixing in the stack is shown in Figs. 12 and 13, which give a plan and a sectional view. In Fig. 13 the bales are placed around the bale breaker and the operator feeds the machine with a pre-arranged amount of cotton from each bale. The cotton from the bale breaker is carried by the elevating lattice to the lattices over the bins. The mixture is allowed to stand for a few days and is then taken in vertical slices. This method is done in order to thoroughly mix the cotton, to allow atmospheric influence to open it, and to permit perfect blending of the different classes of cotton being used.

The following cotton-mixing table for first-class qualities of yarn will be of value—

Under 12's Twist .	Bengal, Sind, broken up cop bottoms, fly and strips from card.
,, 15's ,, .	One Bengal, one Smyrna, and one Chinese, either separate or mixed together.
,, 20's ,, .	One Dharwar, one Dhollerah or Oomra or Tinnevelly, or lower grades of American.
,, 30's ,, .	Better grades of Indian with the strong low classes of American.
,, 40's ,, .	The middling grades of Texas mixed with Rough Peruvian or any Brazilian cotton in small proportions, never more than one-third.
,, 50's ,, .	Good fair Upper Egyptian or higher grades of American cotton, mixed with not more than one-third Maranhams, Santos, Pernams.
,, 60's ,, .	Fully good fair Egyptian.
,, 80's ,, .	Sakelarides Egyptian or very good Abassi. Brown Egyptian is sometimes spun alone owing to its colour. When it is mixed with other cotton there is a danger of producing pinrowed, striped, or streaky yarn.
,, 90's ,, .	Combed Sakelarides Egyptian, or Abassi mixed.
,, 100's ,, and upwards	Combed Sea Island.

Weft counts would be spun one-fourth finer than twist from same mixing.

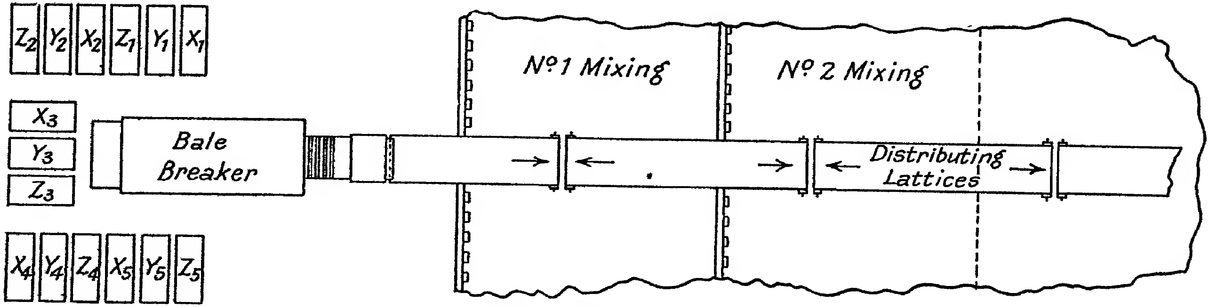


FIG. 12. PLAN VIEW OF STACK MIXING

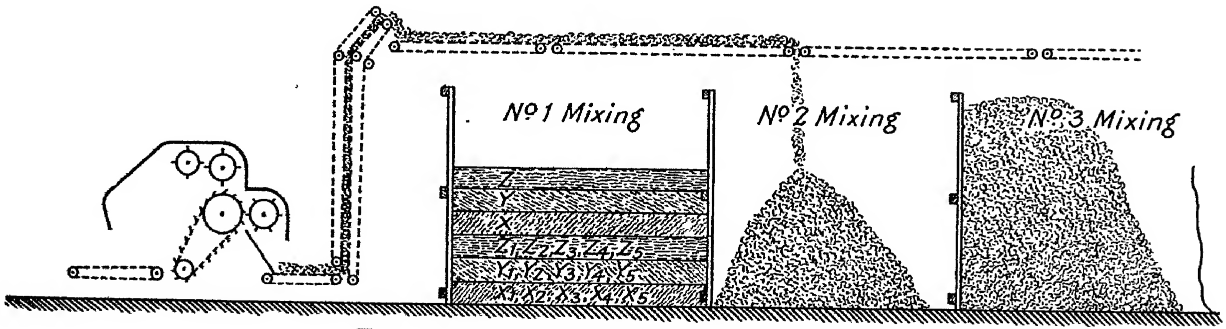
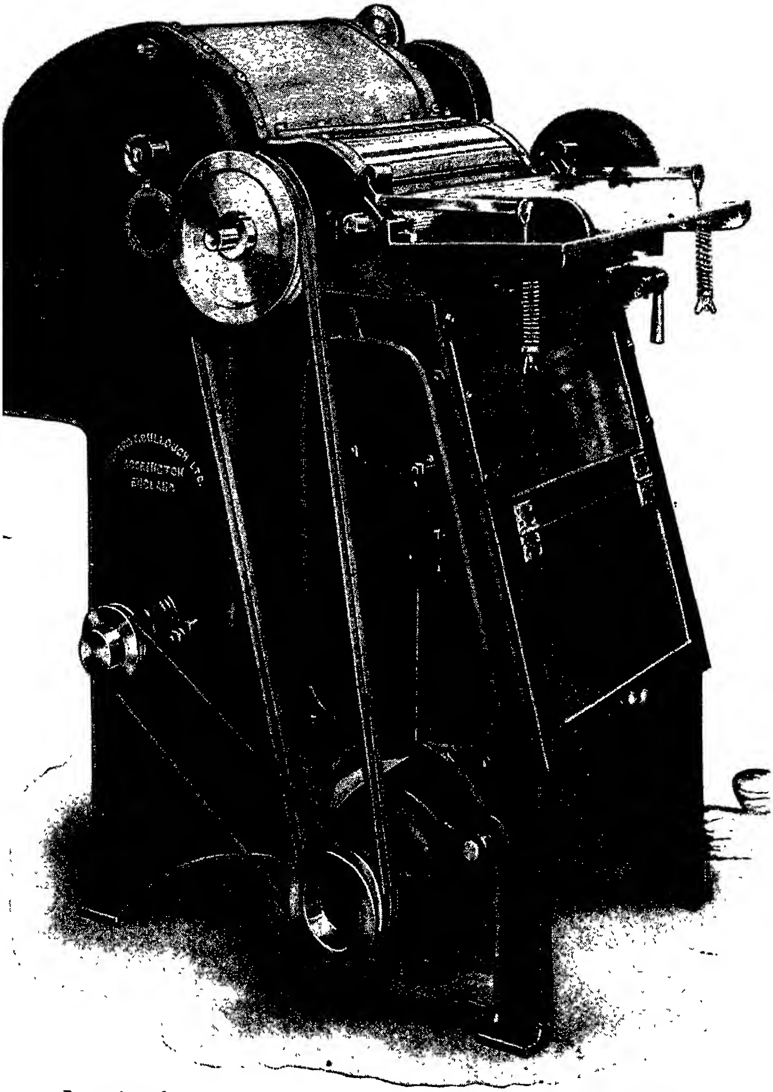


FIG. 13. SECTIONAL VIEW OF STACK MIXING

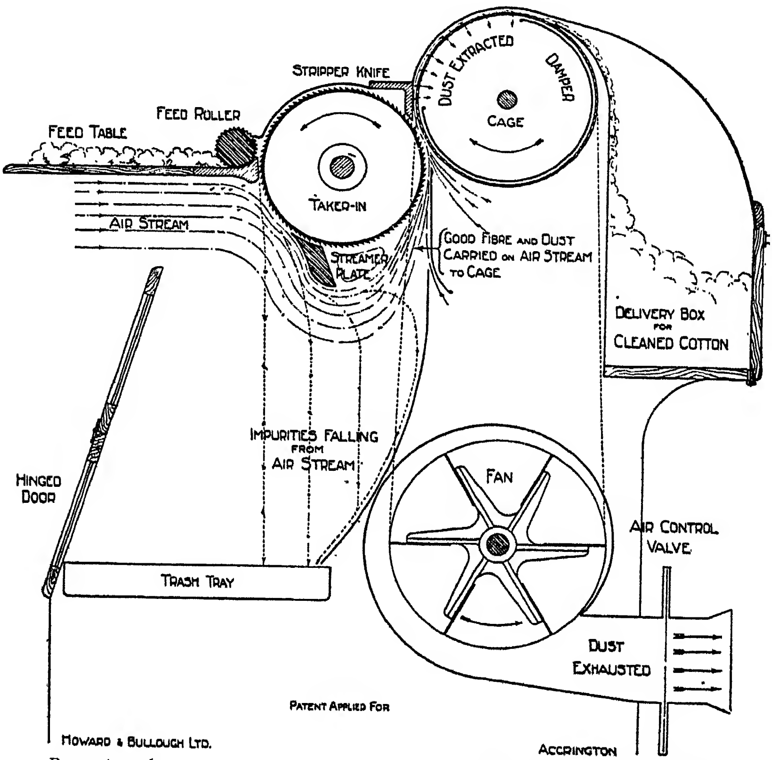


By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 14. SHIRLEY ANALYSER

The Shirley Analyser.

The British Cotton Industry Research Association, after considerable scientific research, has invented a testing machine for the purpose of removing the whole of



By courtesy of *Messrs Howard & Bullough, Ltd.*

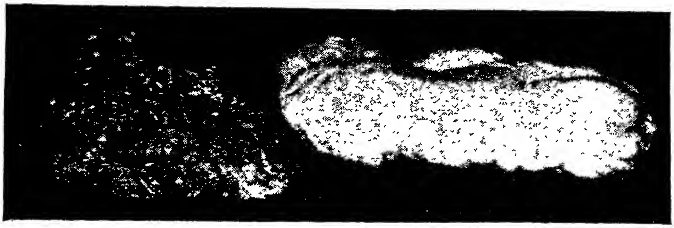
FIG. 15. SHIRLEY ANALYSER—SECTIONAL VIEW

the trash in raw cotton without any appreciable loss of fibre. The spinner, by its use, can take a given weight of cotton and find exactly the amount of trash and dust it contains.

The usual method is to pass 100 lb. of raw cotton through the cleaning process on existing machines and estimate the percentage of trash to fibre. This method

gives only a rough idea, whereas the Shirley analyser gives an accurate one.

The cotton is fed into the machine (Fig. 14), passes beneath the feed roller (see Fig. 15), and is presented



By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 15A. LEFT, SCUTCHER DROPPINGS WITH, RIGHT, LINT RECOVERED FROM A 200-GRAMME SAMPLE

to the taker-in from a specially designed feed plate. Immediately the cotton has passed from the feed plate it is operated upon by the taker-in, which revolves at

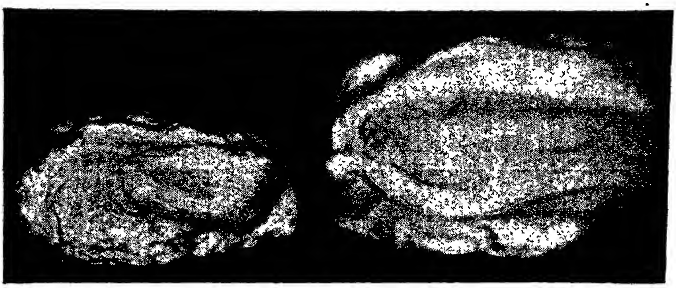


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FIG. 15B. RAW COTTON—TEXAS
LEFT, IN BALE FORM; RIGHT, CLEANED

900 revolutions per minute. The taker-in is clothed with very fine saw teeth, somewhat similar to those of the ordinary card taker-in. On being struck from the feed plate, the cotton is precipitated on to a stream of air, which carries it to the streamer plate. This plate is

in form an aerofoil. The streamer plate causes a ballooning action of the air stream beneath the taker-in, which permits the less buoyant particles of trash to fall into the dirt box. The more buoyant fibre is, however, attracted to the perforated portion of the cage, where it is collected and passed to the delivery box.

The dirt chamber is illuminated, which enables the operator to observe the action around the region of the taker-in and streamer bar, and from his observations make adjustments to the air control valve to increase or decrease the air-stream speed.

Table I shows that after one passage through the machine the cotton is much cleaner than if it had gone through the full sequence of machines in the blowing room.

After two passages it is seen that the amount of impurities is practically nil, and no fibre has been lost.

Table II shows the amount of trash that remains after ordinary processing in the mill to the lap stage.

TABLE I

Raw Cotton	Total Trash Present in Raw Cotton	Trash Extracted by		Residual Trash
		First Passage	Second Passage	
	%	%	%	%
Indian (Bengal) .	12·88	12·48	0·39	0·01
American (Texas) .	12·00	11·28	0·48	0·24
Egyptian (Sakel) .	1·50	1·37	0·10	0·03

TABLE II

Cotton	Form	Lint	Non-Lint
		%	%
American (Texas) . .	Finisher Lap	95	5
Egyptian (Sakel) . .	Finisher Lap	97	3

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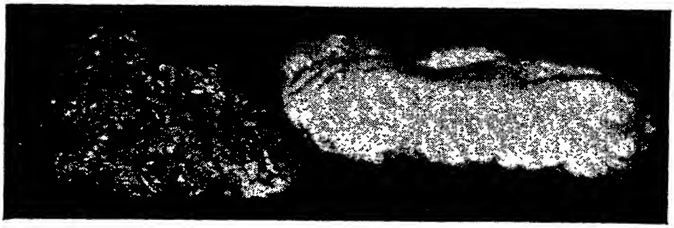

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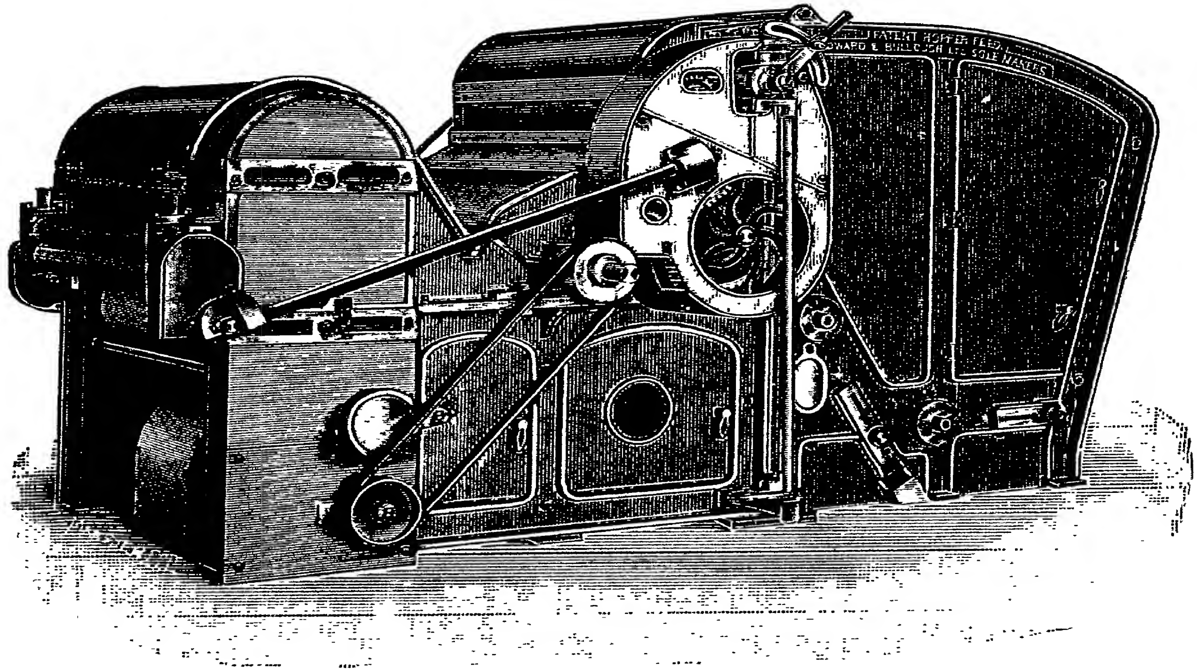
Cotton Opening : Hopper Feeder.

The mixed cotton is taken from the stack in vertical sections, so as to get mixed in every armful a small portion of cotton from each bale. This is with the object of securing uniformity in the yarn. A mixing that will last a week is preferred to one that will last a day, and whilst one mixing is being used another is in process of making. This gives time for the evaporation of any dampness that may be in the cotton. The cotton from the mixing is generally placed upon a travelling floor lattice of sufficient length to suit local conditions. This carries the cotton forward into a hopper feeder box, Fig. 16. The object of this feeder is to pull the cotton finer and to clean it a little, but principally to deliver it upon the porcupine opener feed lattice (Fig. 17) in an even sheet. The feed lattice carries the cotton to a pair of feed rollers, from which it is struck by a porcupine cylinder about 36 in. diameter and 45 in. wide, and which runs at about 500 revolutions per minute. The force of the blow given to the cotton by the beater drives it against dirt bars, set in a circular position underneath the beater. Whilst dirt is driven out the cotton is carried forward by the strong air current through dust trunks. If damp cotton is placed in the opening machines it causes them to choke up, and also tends to string and nep the cotton, whilst the dirt does not come away as when the cotton is in a dry state.

The dust trunks are about 4 ft. long, 12 in. wide, and  shaped. As the cotton passes through, the dirt falls down between thin plates. At the base of the trunks there are hinged air-tight doors, which are opened once or twice a day to remove the accumulations. There are generally about half a dozen of these dust trunks or dirt boxes in the range between the bale breaker and opener, the number varying according to the space available. From the trunks the cotton enters into another beater chamber, where another beating and cleaning process goes on. Then it is collected by a pair of dust

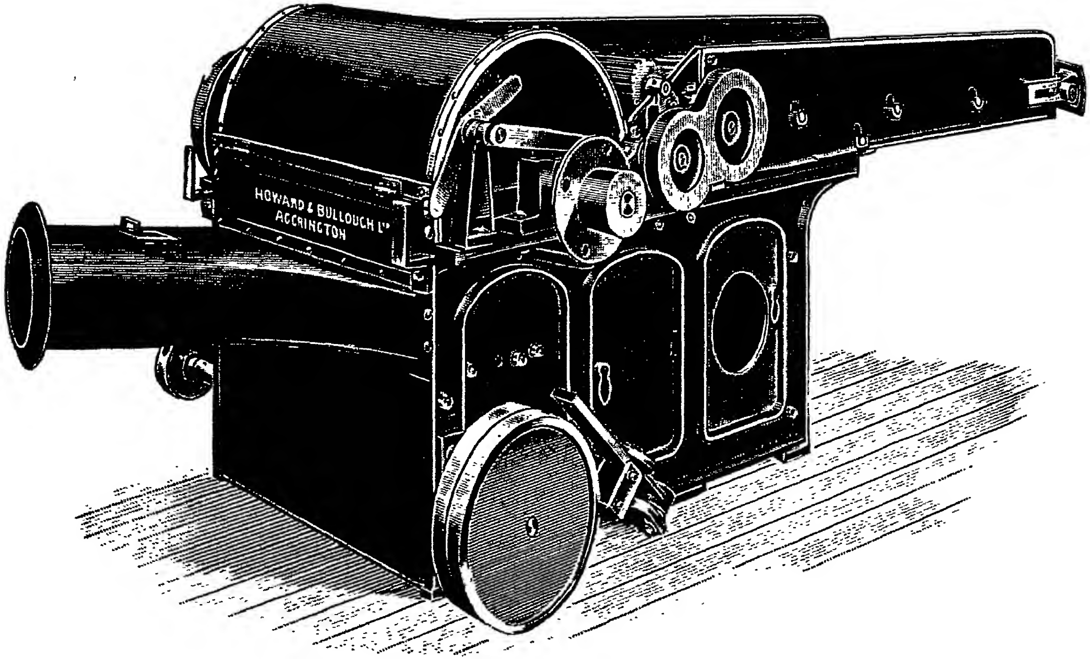


By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 16. HOPPER FEEDER

cages, drums made of perforated sheet metal, or fine-meshed wire netting. The ends of the cages are open to a dust flue, down which a fan forces a strong air current. This produces a partial vacuum inside the cages, causing the cotton to fly on the outside of the cages, whilst the fine dust and impurities pass through the perforations into the dust flue below. It is important that the construction of the flues offers no obstruction to the passage of the air. The dust cages pass the cotton on to pairs of cage rollers, and then on to one or two pairs of feed rollers, from which it is struck by a two or three-bladed beater revolving at a rapid rate. A two-bladed beater revolves at about 1,300 revolutions, and a three-bladed beater at about 900 revolutions per minute. These beaters are very carefully made, well finished, strong, and perfectly balanced. The edges of the striking blades are bevelled to a point, so as to open and clean the cotton better. After these beaters have been working a number of years the bevel edge gets worn off and has to be resharpened or replaced. For the finer and better qualities of cottons some prefer the three-bladed beater for the reason that the same number of blows are given to the cotton per minute as with a two-bladed beater, and the force is therefore less. This is an advantage for the finer grades of cotton.

The beater strikes the cotton against the dirt bars. The dirt, being heavier than cotton, takes up a greater percentage of the energy of the blow given by the beater and is consequently driven out. The cotton is carried forward by the air current rushing through the spaces in the dirt bars and delivered upon a second pair of dust cages, which collect the cotton into sheet form. Then it is passed on to the cage rollers, and calender rollers consolidate the sheet so that the liability to "licking" at the next process will be less. From the calender rollers the cotton sheet is delivered to the lap rollers, which wind it up into lap form, and by means of a lap-compression motion, which consists of a rack, train of wheels,



By courtesy of Messrs. Howard & Bullough, Ltd.

FIG. 17. OPENING PORCUPINE FEED TABLE WITH LATTICE

and brake-pulley, the lap is wound up very tightly and is easy to handle at the next process.

The production of a hopper feeder is the capacity of the opener to take the feed, and amounts to about 30,000 lb. per week of 48 hours.

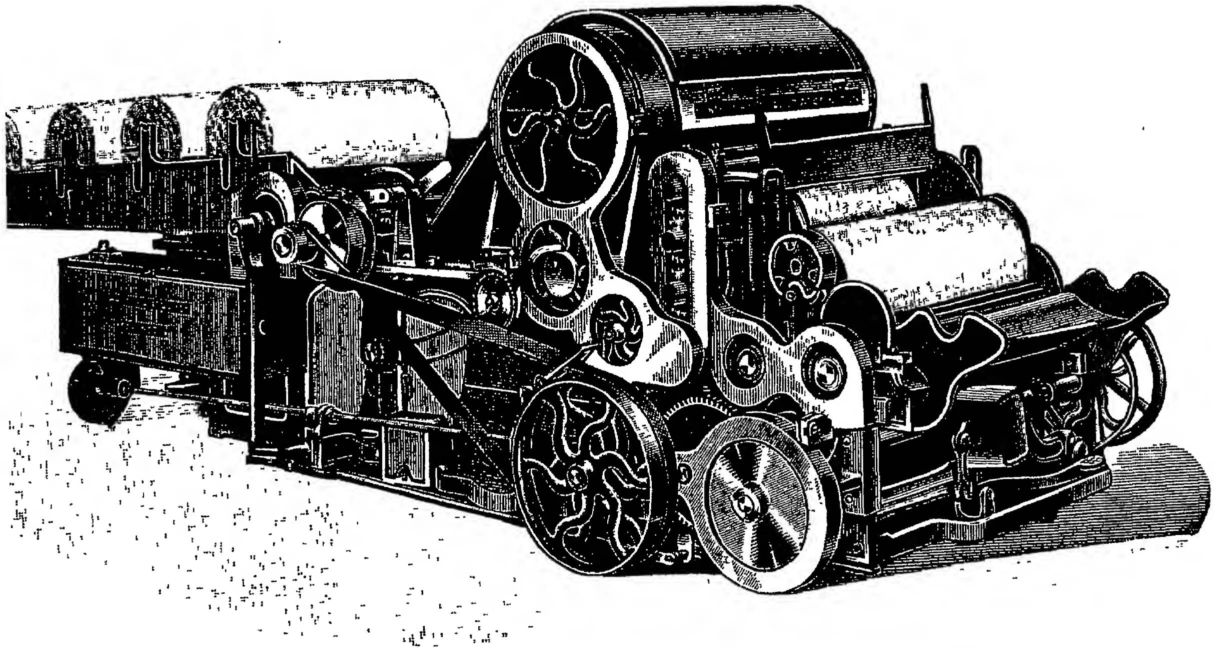
The cotton can be fed into this machine either by hand or by a slow-moving lattice from the previous machine. If the mixings are in a room above, as is often the case, the cotton is usually fed by a lattice and pipe to the hopper feeder.

This machine automatically feeds a regular weight of cotton to the scutcher after opening it a little and removing more dirt.

The Scutcher.

The object of the scutcher (Fig. 18) is to further clean and open the cotton, to improve the regularity of the opener laps, and form the cotton into laps of uniform weight and density ready for carding. It used to be a common practice to have an intermediate scutcher for American cotton, but since the introduction of the hopper feeder the intermediate scutcher is not considered necessary. The less cotton is beaten and worked, so long as it is clean and sufficiently opened for the card, the stronger the yarn obtainable.

The opener lap, which generally weighs about 40 lb., and is about 45 yds. long, is put upon the feed lattice of the scutcher. Generally four laps are doubled. This helps to make the finished lap more uniform in weight yard per yard. The doubled laps are fed to two pairs of feed rollers, or one pair of feed rollers and another roller with pedal levers under the roller which forms part of the piano-feed motion. From these rollers or pedal nose the cotton is struck by a heavy revolving beater. Dashed against the dirt bars, the impurities in the cotton fall through. The cotton collected by a pair of dust cages passes to a pair of conducting rollers and four lines of calender rollers, which compress the sheet of



y courtesy of Messrs. Howard & Bullough, Ltd.

FIG. 18. SINGLE SCUTCHER AND LAP MACHINE

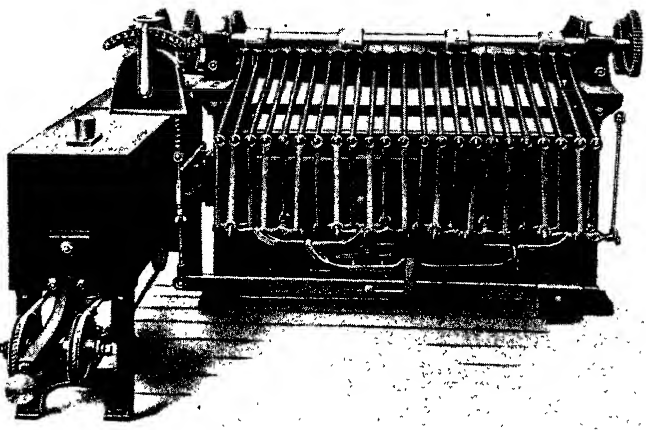
cotton, after which it is wound up in lap form ready for the carding engine.

There are several motions about a modern scutcher which require dealing with separately, such as the piano-feed motion, knocking-off or measuring motion, the arrangement for weighting the calender rollers, and the driving of the different parts of the machine.

Piano-feed Motion.

The object of this motion (Fig. 19) is to regulate the speed of the feed rollers to compensate for any variation there may be in the thickness of the opener laps. The motion consists of a feed roller, under which are placed a number of pedal levers. The nose of the pedal is specially shaped (if the cotton is struck from it) to suit the length of the fibre, so as not to damage the cotton. If the cotton is not struck from the pedal nose, but from a pair of feed rollers, then the regulating pedal is placed behind the feed rollers and does not need to be specially shaped at the nose. Whichever may be the case, the pedal lever is fulcrumed several inches from the nose. The tail end of the lever, of which there are about sixteen, is hooked, so as to hold a vertically hung pendant lever, the lower end of which is wedge-shaped △. These wedge-shaped parts hang between anti-friction bowls. The end pendant is slotted and to it is connected a lever which, through a connection of levers, moves a leather belt, which drives the feed roller through a train of wheel and cone drums. If a thick place in the lap comes under the feed roller it depresses the pedal lever, swivels round the fulcrum, lifts up the tail end, which also raises the pendant lever, and the movement continues through the bowl box to the last lever in the series and onwards to the cone drum belt, thus moving the position of the belt on the cones to drive the feed roller slower and compensate for the extra thickness going through. If a thin piece is going under the feed rollers the opposite effect is obtained. The feed roller is speeded up to neutralize the thin place.

The greatest defect in connection with the piano-feed motion is the trouble of having to clean the bowl box out every few weeks, also the bowls sticking and flat places wearing on them. If the bowl box is not kept clean, and the bowls in good condition, the object of the motion is neutralized. Many different arrangements of bowls have been tried with a view to reducing friction



By courtesy of *Messrs. Platt Brothers & Co., Ltd.*

FIG. 19. SCUTCHER PIANO-FEED MOTION

in the bowl box, and a few years ago one important machine-making firm introduced an arrangement to discard the bowls and bowl box altogether, and substitute a tripod arrangement of levers and links. This method has had a very wide adoption and is giving good results, especially when a hopper feed is used.

In some of the old scutchers there were two calender rollers, but in all modern machines (unless specially ordered) there are four calender rollers. The four calender-rollered machines give better consolidation to the laps. The calender rollers are also made with a slightly different surface speed so as to polish and smooth the consolidated

sheet of cotton. It is important that all lap rods used for laps should be exactly the same weight. If they are not, one is led astray in weighing the full laps.

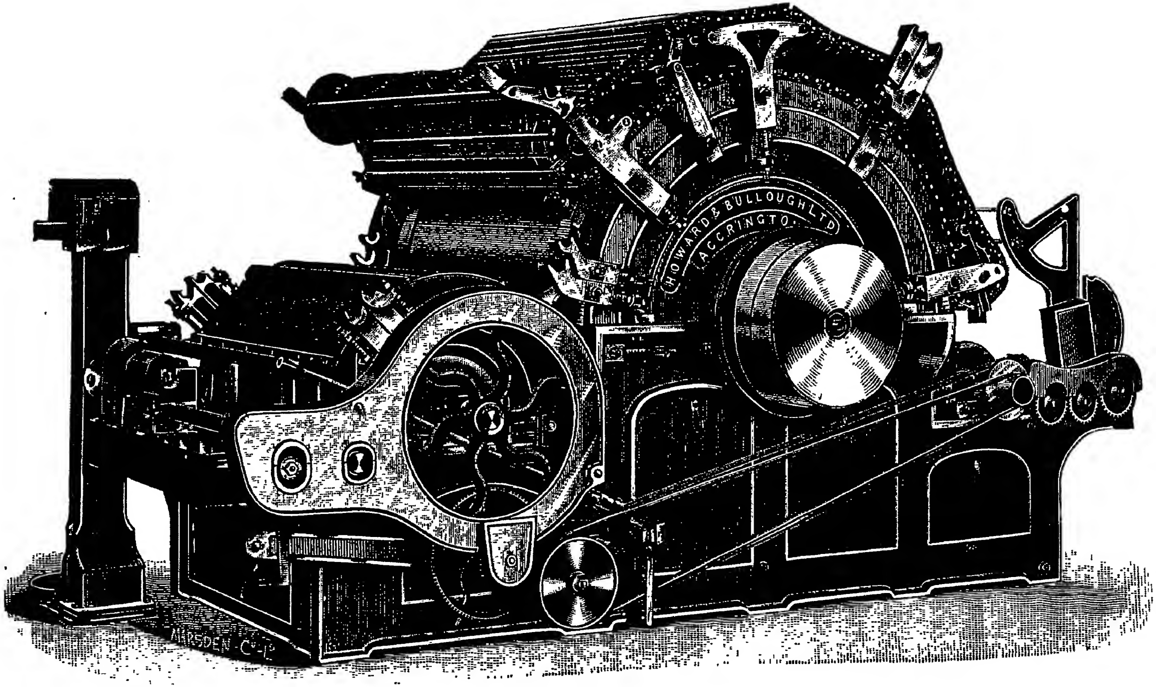
On most openers there is a knocking-off motion, which ensures the laps being uniform in length, and enables the weights to be easily compared. The finished laps at the scutcher weigh about 30 lb. each, and any lap weighing 4 oz. lighter or heavier than this standard weight should be rejected for irregularity. In some cases these bad laps are sent back to the mixing room, or a heavy and light lap may be put on the creel of the scutcher lattice again and made into a fresh lap.

It is not absolutely certain because the total weights of the laps are equal that they are good laps. Generally speaking, this would be so. At the same time, it is possible that the total weight of the lap is right, but the lap yard per yard very irregular. Owing to this being possible, there are wooden gauges for measuring off two-yard lengths. The whole lap is sometimes measured in two yards and re-weighed. If the lengths then weigh equal it is proof that the machine is working well.

In both scutchers and openers it is important that all parts should be kept well oiled and cleaned. If this is not properly attended to there is the liability to fires, irregular laps, lap-licking or splitting, and bad selvedges. All parts of the machine with which the cotton comes into contact should be periodically black-leaded, to make them smooth so that the cotton may not adhere.

Carding.

The objects of the carding engine (Fig. 20) are (1) to remove all impurities, either natural or foreign, in the cotton which have escaped the preceding processes; (2) the extracting of all short, immatured, broken, or nepped fibres, the retention of which would weaken or otherwise reduce the quality of the yarn; (3) to disentangle the confused mass of fibres and lay them approximately in parallel order; (4) to attenuate or draw out the heavy



By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 20. REVOLVING FLAT CARDING ENGINE

sheet of lap into a thin fleece or film and contract it into a strand or "sliver" fitted for the next process.

The impurities are husks, shell, seeds, bearded motes, leaf, neps, and dead or unripe cotton. The whole or most of these impurities are forced into the card wire, and periodically stripped out by a comb working in connection with the flats. A brush strips the impurities from the cylinder and doffer. The short fibres, not being of sufficient length to be held by the card teeth, are thrown off, into the flat-teeth, or through the undercasing of the licker-in, or cylinder.

The drafting and the collecting of the fibres from the doffer, and guiding them through a funnel and calender rollers, constitute the making of the web into a sliver.

Bearded motes, neps, and leaf are the impurities most difficult to extract in the card. As previously indicated, bearded motes are unginned, broken seeds, and broken seeds which have short hairs on them after ginning. The short hairs on the outside of the broken seeds stick to the cotton and are difficult to extract.

Neps are a small number of fibres rolled together, forming a ball about the size of a pin-head. These neps may be caused by bad ginning, overbeating at the scutchers, or bad carding, and they adhere to the cotton tenaciously.

Leaf is very light, breaks up into fine pieces, and is very difficult to get rid of. It is only by subjecting the cotton to the process of combing that perfectly clean yarn is obtained.

The removal of the above-mentioned impurities, which are natural to cotton, shows how very important the process of carding is, as upon its being done well depends the success of every process that follows.

Many years ago there used to be a system of double carding by a roller and clearer card. This is now obsolete and has been superseded by the revolving flat card and the comber. The revolving flat carding engine (Fig. 20)

gives double the production and a better carded sliver, more cheaply produced.

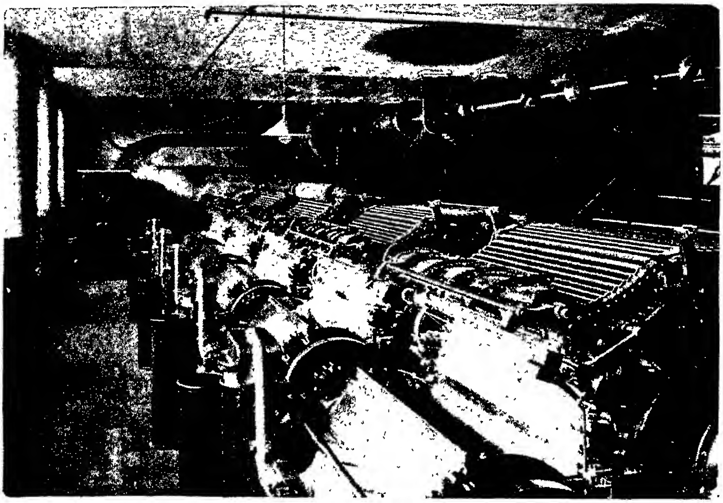
Let us now see how the cotton lap is further opened and cleared in passing through a revolving flat card.

The scutcher lap is placed upon a fluted lap roller, which, by revolving, causes the lap to unwind. The end of the lap is guided under a feed roller about 2 in. in diameter. Under the feed roller is a dish-feed plate, the nose of which is curved to suit the curvature of the feed roller, and the length of the nose is made to suit the length of the fibre being carded. Whilst the cotton is held by the feed roller and dish-feed plate, the cotton is combed out by the teeth of the licker-in, the points of which are set to about $\frac{7}{1000}$ths of an inch from the nose of the dish-feed. At this point the material is attenuated or drafted out about 2,000 times, so that the lap sheet is converted into a very thin film. Underneath the licker-in are two mote knives for clearing off the fragments of seeds on the surface of the fleece of cotton being carried round. Close to the teeth of the licker-in there are also dirt bars, where fine impurities and short fibres pass through into the dirt chamber below. The cylinder has about double the surface speed of the licker-in, and its wire teeth are bent forward in the direction of motion, and set to about $\frac{7}{1000}$ths of an inch from the licker-in teeth. The cylinder strips the licker-in of its fibres and carries them on to the flats. Generally, there are about 110 flats on a card, and forty-four of these are always carding when the card is working. The flats wire has what is called a heel and toe when carding. The wire where the cotton enters is about $\frac{1}{50}$th of an inch from the cylinder wire and is called the toe. The heel is where the cotton leaves the flat and is set to about $\frac{1}{100}$th of an inch from the cylinder wire. The object of this heel and toe in the flat wire is to allow the cotton to enter under the flat easily without rolling and forming neps, and the heel, being nearer the cylinder wire, gives the fibres a progressive carding. The flats are the main carding part of a carding engine. As

the cylinder carries the fibres under the flats they tend, through centrifugal force, to fly out, and in doing so come in contact with the flat teeth which comb and clean the fibres from many of their impurities. After the cotton has passed under the forty-four flats it comes to a stripping plate, which separates the fibres as they leave the flats. Very much depends upon the setting of this plate whether there are heavy or light strips. The nearer this plate point is set to the cylinder wire the lighter the strips will be. The cylinder carries the cotton onward to the doffer, which has about thirty times less surface speed than the cylinders. It runs in the opposite direction to the cylinder, and its wire teeth are set in an opposite direction to its motion. It is set to about $\frac{5}{1000}$ths of an inch from the cylinder wire and, collecting the fine web from the cylinder, carries it underneath to the front, where it is stripped by an oscillating comb set close to the wire teeth. The web is next guided to a trumpet mouth, which condenses it into a thick sliver. Then it passes through a pair of calender rollers and coiler rollers, down the tube wheel, and is wound spirally into the sliver can, which runs in the opposite direction to the coiler and at a much slower speed. The variation in speed, and the setting of the can-plate in relation to the coiler, winds the material into the can in a very beautiful manner. The object of winding it in after this fashion is to get a greater quantity of sliver into the can, and to enable it to be pulled out at the next process without entanglement and breakage.

The filleting for the card is made in lengths, so that one length will cover the doffer or cylinder. The foundation of the filleting for doffer and cylinder is generally made up of one layer of woollen sandwiched by two outside layers of cotton cloth of very good quality. These layers are securely cemented together by india-rubber cement, and finished off with a top layer of pure india-rubber. The object aimed at is to get a firm foundation for the wire and at the same time to have a little elasticity in it.

For the flats there is used the same foundation, but without the layer of india-rubber at the top. It would not do to use the india-rubber for flat foundation, because the flat has no protection from the rays of the sun. The



By courtesy of *"The Illustrated London News"*

FIG. 21. CARD ROOM, SHOWING MOTOR

cylinder and doffer are more protected and cased in than the flats. Fig. 21 shows a card room.

Section of Card Wire.

Many different sections of card wire have been tried for card clothing, viz. round, plough ground, flat, side ground, convex, etc. All the sections, except round and plough ground, have been discarded because of their weakness and working loose in the foundation. The object of these different sections is to supply a wire that will keep sharp at the point without having to be ground frequently, and also to provide more space between the

wires for the accumulation of dirt, and thus reduce the need for frequently stripping out. Experience has proved that plough-ground wire (that is, wire of a round section, but ground down the tooth almost to the knee) is all that is desired, though some people using the better qualities of cotton prefer the surface ground—that is,

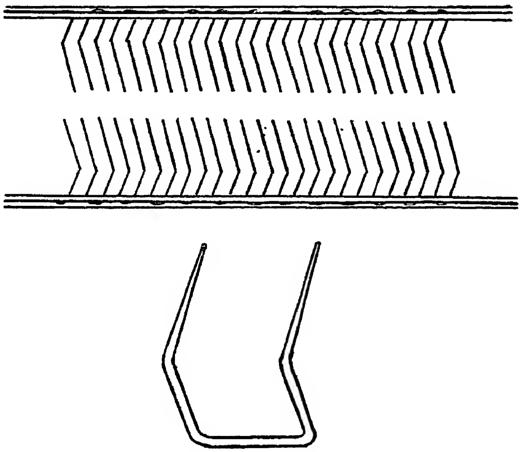


FIG. 22. CARD CLOTHING, SHOWING INDIVIDUAL WIRE STAPLE

wire of a round section with the sides close to the face of the wires ground to a point.

Fig. 22 gives a rough view of the wires in their setting, and there are about four millions of wires in one machine.

The counts of card wire are based on the number of points in 1 in. length, and 4 in. width of the filleting. If the number of crowns per square inch is divided by $2\frac{1}{2}$ it equals the counts of wire.

Counts $\times$ $2\frac{1}{2}$ = crowns per square inch;
Counts $\times$ 5 = points per square inch;

so that if the counts of card clothing are 100's we should have 500 points per sq. inch.

The counts of wire used for different cottons are—

	Cylinder	Doffer	Flats
Indian	100's	110's	110's
American . . .	110's	120's	120's
Egyptian . . .	120's	130's	130's
Sea Island . . .	120's	130's	130's

The licker-in is generally covered with a metallic saw tooth covering, and has about eight teeth per inch in width and four teeth per inch circumferentially.

Grinding of Cards.

To ensure good work from carding engines the card-wire must be kept sharp. This is done by grinding the card-wire with revolving rollers covered with emery cloth. The rollers are made to have a lateral traverse, so as to grind the side as well as the top of the wire. Grinding each card once per fortnight for several hours should keep the wire in good condition.

A more modern grinder is now in use, which has the abrasive substance chemically fixed on to the rollers in such a manner that it gives a hard, rigid surface and is not affected by the changes in the atmosphere, as is the case with the emery-cloth method.

The illustration (Fig. 23) shows the weighted lever *A* centred at *B* on the fixing plate *D*. When the weight *C* is placed in position the finger A^1 is raised against the rib of the flat to be ground, pressing it into contact with the controlling plate *F*, which is firmly fixed in position. The flats ride on the upper surface of the plate *D* until they come under the influence of the finger A^1. Each half of the controlling plate *F* is in a different plane, with a step from one to the other in the centre, so that when one edge of the working surface of the flat end is on the one plane the second edge is on the other plane (the position when grinding is taking place), and the flat wire is kept in the

A wheel fast on this shaft drives the spindle shaft by a large carrier wheel, and fastened on the spindle shaft are skew bevel wheels driving the spindles. The twist wheel, also screwed fast to this shaft, drives the top cone drum shaft and front draft roller. The second and third draft rollers are driven from the front by gearing. The bottom cone drum, which gives the excess speed to the bobbin and drives the lifter rail, gets its motion from the top cone drum by a belt. The gearing of the driving to the spindles and bobbins is such that when the bottom cone drum is stopped the spindles and bobbins run at the same speed. It is this arrangement of speeds that enables the ends to run slack for doffing purposes. The variable excess speed required for the bobbin to wind the material on is given to it by the revolution of the bottom cone drum. Variable speed is given to the bobbin rail, which is necessary to keep the coils of rovings equally laid.

The gauge for the above machines are generally as follows—

	Spindles	Inches
Slubbing Frame . .	4	19
Intermediate Frame . .	6	17¼
Roving Frame . . .	8	20½
Jack Frame . . .	8	17½

These gauges vary according to the counts, being closer for fine than for coarse counts.

Doublings at the Fly Frame.

There is never doubling of ends at the slubbing frame because of the great difficulty in dealing with double the number of cans at the back of the machine. At the intermediate, roving, and jack frames, two bobbins are doubled to one end, to minimize the irregularity at the slubbing. We have the creels arranged at the next processes, so that it makes it very convenient to double.

 by Peake, R. J.

There are always single boss rollers at the slubbing, but there may be single or double boss rollers at the intermediate, roving, and jack frames. Single boss rollers tend to better work. The advantage in using the double boss is that there is required only one-half the number of rollers, weights, and weight hooks, and consequently less work in scouring and cleaning.

Standard Twist put in the Material at the Fly Frames.

It is impossible to give arbitrary rules for twisting the material at the fly frames, because the twist has to be varied to suit the character of the cotton and the working condition of the frame. Although the hank being made may be the same, what is done in these frames is to put as little twist in as possible, so long as the sliver pulls the bobbin round at the next process without breaking. If more twist is put in than is required the production of the frame will be reduced, the leather top roller will wear out sooner, and the drawing will be more irregular. That part of the fly frame which supports and carries the bobbin is called the collar. There are two different kinds used—long and short. There are two systems of winding the rove on the bobbins at these fly frames, namely, bobbin-to-lead and flyer-to-lead. The latter system is now almost obsolete; the former is becoming general. The cone drums on the fly frames, as well as the scutchers, have to be concave and convex in form to give correct winding and feeding.

Spinning Machines.

There are three different types of spinning machines, viz. the flyer throstle, ring frame, and mule. The objects of all three are the same—to reduce the rovings to the required fineness or counts, to give them an amount of twist which depends upon the kind of yarn being made and the purpose for which it is intended; also

to wind the yarn upon a double-flanged bobbin on the throstle frame, and on a bobbin without flanges if spun on a ring frame, and on the bare spindle or on short, thin paper tubes if spun on the mule. All these machines have three lines of top and bottom rollers, the bottom line steel-fluted and the front top line covered with cloth and leather, whilst the middle and top back rollers are generally highly polished, self-weighted rollers, without leather covering. Spinning machines generally have about 1·2 of a draft between the back and middle lines of rollers and from five to eight of a draft between the front and middle lines. The latter draft is the break draft, and varies according to the counts of yarn required.

Flyer Throstle Frame.

The flyer throstle frame is used exclusively for twist yarns up to about 40's. Yarn spun on this machine is known and sold as "water twist" from the fact that the first throstle machine was driven by a water-wheel. To spin yarn on this frame a good class of cotton is required for the counts being spun, with plenty of twist, in order to pull the bobbin round in the spinning process. The method of winding the yarn on, in this machine, is the same as in the flyer-to-lead principle in fly frames, with the exception that when an end breaks the bobbin stops, whereas in a fly frame it keeps on running. Yarn spun on flyer throstle machines has a good reputation; in fact, it is impossible to spin a poor, soft, weak yarn on them. Every inch of yarn is tested in strength on these machines by the yarn having to pull the bobbin round at about 5,000 revolutions per minute.

The flyer throstle frame consists of a creel, sometimes a flat table creel and sometimes a vertical one, in which the roving bobbins are placed. The rovings are passed over guide rods and then through traverse guides and onwards to three lines of top and bottom drawing rollers to draw the material to the required fineness. When it emerges from the front draft roller it is passed down·

to a flyer which is screwed upon a spindle. The flyer twists the yarn and winds it on the bobbin.

The flyer throstle frame is very similar to the ring spinning frame, and is very seldom seen to-day as the ring frame has taken its place. The difference exists in the spindles and the manner by which twist is put into the yarn. In the flyer there is a spindle like a plain steel rod fitted with a flyer, and the revolutions of this determine the amount of twist.

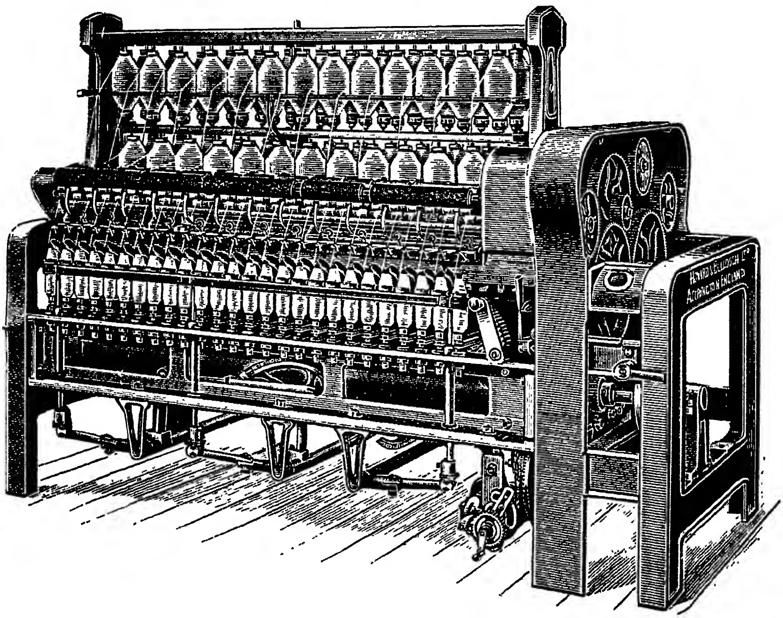
Ring Frames.

Comparing the three different systems of spinning, it may be said that the spindle speed in a flyer throstle frame is only about 5,000 revolutions per minute. It takes more power for the same number of spindles, and there are fewer spindles in the same space as compared with a ring frame. It takes more time for doffing and more oil per spindle. The ring frame (Figs. 34 and 34A) spindle revolves in a bath of oil that will last without replenishment for a number of weeks.

The ring frame spindles run at from 8,000 to 10,000 revolutions per minute, thereby giving a much greater production than the flyer throstle. The ring frame is a continuous spinner, the twisting and the winding going on simultaneously. The mule is an intermittent spinner. It draws the roving and twists the yarn as the carriage comes out, but the winding on is done when the mule is running in to the roller beam. The ring frame is a much simpler machine than a mule. The mule can spin a softer yarn than the ring frame, and upon the bare spindle.

The ring frame has made very rapid progress of recent years, both in this country and on the Continent, for the spinning of twist yarn up to about 60's and weft up to about 30's. The great defect in this machine is that the yarn has to be spun on a small bobbin or long, thick paper tube. This prevents the yarn being used except on the premises where the yarn is spun, because it is too

costly in carriage on broken bobbins, if the bobbins are returned. New mills that have part mule and part ring frames have a reeling, winding, and warping department, so that the yarns may be sent away in bundles or on back beams. In some cases manufacturers have thrown out their winding and warping frames and filled up the

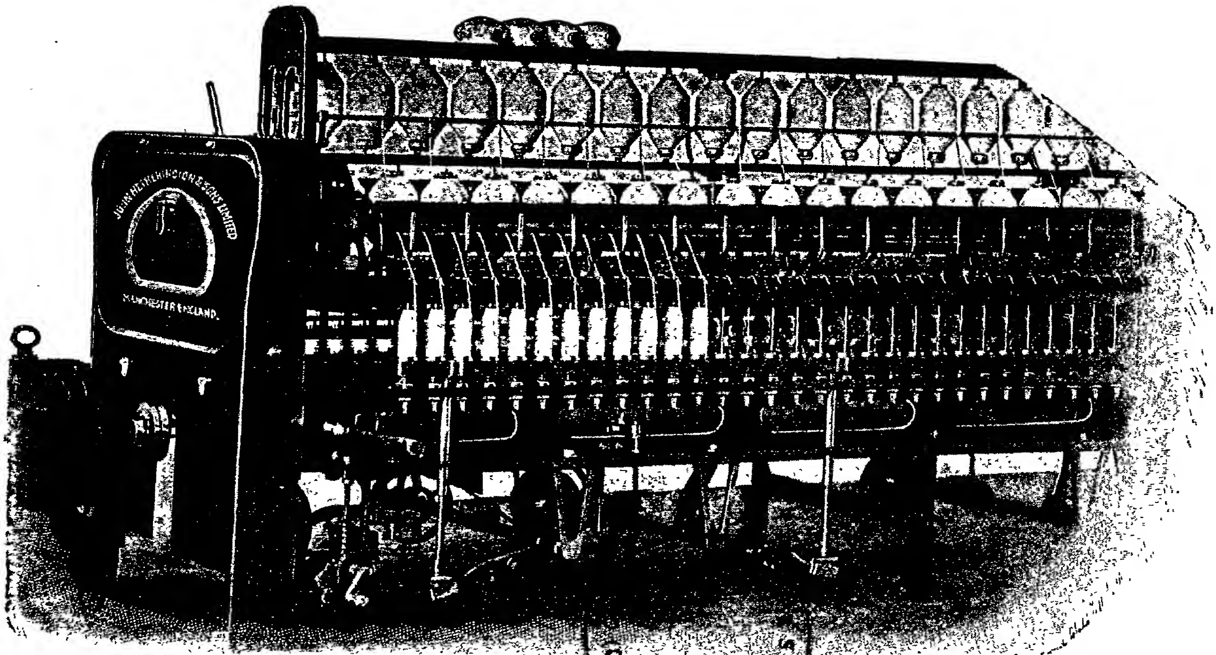


By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 34. TWIST RING SPINNING FRAME

space with new looms, having found it to be more profitable to buy the yarn in back beam form and so increase their production by more looms.

The ring frame may be driven by a belt or rope from the line shaft. This drives the tin roller, which in turn drives the spindles by a spindle band. Fixed upon the tin roller shaft is a compound wheel which drives through a train of wheels the cam which gives motion to the ring rail and shapes the yarn wound on the bobbin, and it



By courtesy of *Messrs. John Hetherington & Sons, Ltd.*

FIG. 34A. RING SPINNING FRAME
Made to contain from 180 to 564 spindles.

also drives the middle and back draft rollers. The cam is so made as to cause the downward movement to be accomplished in one-half the time of the upward movement of the bobbin rail. This is designed to give a binding thread to the body of the yarn, which causes the yarn to come off more freely when unwinding.

The traveller of the ring frame, which varies in weight according to the counts of yarn being spun, clips the ring and revolves one revolution every time the spindles make a revolution minus the retardation necessary for winding the yarn on the bobbin. The ring also varies in diameter according to the counts being spun. The finer the counts the less the diameter of the ring. The lift is also less for finer counts. The traveller puts the twist in the yarn, as well as winding it on the bobbin, by running slightly slower than the spindle. The yarn is wound on the bobbin after the style of building a cop at the mule. On the rings' rail of the ring frame there are small pieces of wire with sharp edges set close to the path of the traveller when revolving round the ring. The object is to clean off the fibres and fluff that accumulate on the traveller and thereby improve the spinning.

Separators.

The object of separators (Fig. 35), or pieces of plate projecting between the bobbins, is to reduce the amount of ballooning in the yarn caused by the revolution of the bobbin and traveller giving a centrifugal force to the yarn. The great defect in a ring spinning frame, and the one which has prevented its superseding the mule to any large extent, is the fact that this machine cannot spin yarn commercially upon the bare spindle. But experiments are constantly being made to secure this.

The Mule.

As previously indicated, the object of the mule is to draw the rovings into the required fineness, to twist the yarn to give it strength, and to wind up on a short paper tube or on the bare spindle as may be required. In this

(a)

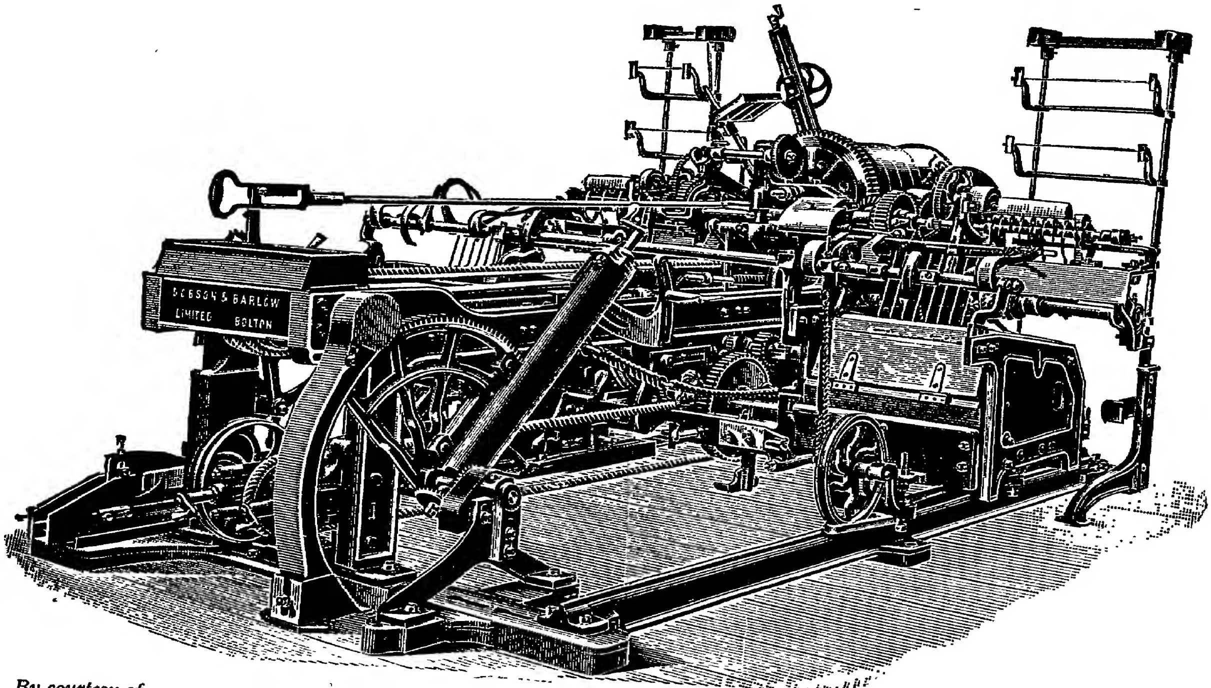
(b)

By courtesy of Messrs. John Hetherington & Sons, Ltd.

FIG. 35. BLINKER SEPARATORS: (a) OPEN, (b) CLOSED

machine there can be spun a softer yarn, from a lower class of cotton than that used on the throstle or ring frame, because the machine handles the yarn more gently. Another feature of some importance is that in the throstle or ring frame the yarn is wound on as it leaves the front draft rollers, but on the mule the yarn can be made more level after it has left the front draft roller.

The modern mule (Fig. 36) is much longer than mules put in forty years ago, when a twist mule was about 750 spindles long and a weft mule 900 spindles long. To-day twist mules are made to contain about 1,100 spindles with a gauge of $1\frac{3}{8}$ in., and weft mules have now about 1,300 spindles of $1\frac{1}{8}$ in. gauge. A full-size twist cop spinning 60's twist would be about $7\frac{1}{2}$ in. long and $1\frac{1}{4}$ in. diameter. A weft cop spinning 80's would be $4\frac{3}{4}$ in. long and $\frac{3}{4}$ in. diameter. The finer the counts spun, the shorter and less diameter will be the cop. The stretch of a mule (that is, the distance the spindle point moves outwards each draw) varies according to the counts spun. The finer the counts, the less the stretch. For about 30's to 60's there is a 64-in. stretch, and for finer counts as low as a 58-in. stretch. The larger the stretch the more is reduced the piecing capacity of the spinner, besides getting worse spinning. As large a stretch as is consistent with good spinning and management must be secured or the production is reduced. In many mills the draft rollers revolve during the time the carriage is running in, with a view to increasing the length of yarn delivered per draw by about 3 in. This is equal to having a 3-in. longer stretch so far as production is concerned but without the disadvantage of a long stretch. The spindles in a mule carriage do not stand up vertically, but the points are inclined towards the roller beam. This is what is called bevel. In finer counts there is required more bevel than in coarse counts. It is advisable to have as much bevel in the spindle as possible, so long as the yarn does not slip off the spindle blade during spinning, causing



By courtesy of Messrs. Dobson & Barlow, Ltd.

FIG. 36. SELF-ACTING MULE

snarls. Snarls are loops in the thread and are very objectionable to the manufacturer.

Cross-wound Cops.

There are many winding machines in use to wind yarn from the mule cop straight-wind into a cross-wind. This,

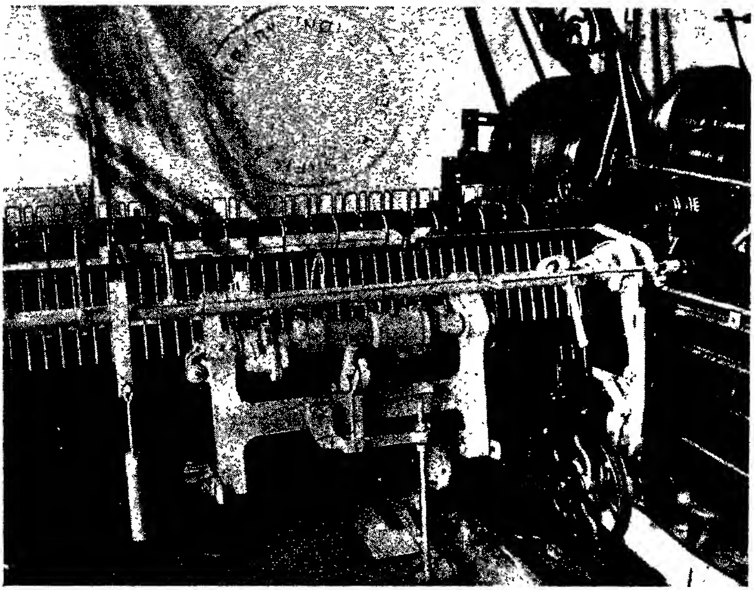


FIG. 37. STAFFORD GOLLAND MULE CROSS-WIND

of course, is an extra process in the preparation of yarn for weaving. Figs. 37 and 37A illustrate the "Stafford Golland Mule Cross-winding" invention as made by Messrs. Asa Lees & Co., Ltd., Oldham, which does the work of cross-winding directly on the mule itself. This patented mechanism can be applied to all mules of whatever make. It is fixed on the mule carriage, as shown in Fig. 37, and is entirely automatic in its working, requiring no attention from the minder.

The mechanism winds the yarn on to the spindle in

widely pitched spirals, in each direction, on the chase or nose of the cop from the first coils on the spindle until the cop is completed. By this system the present difficulties of winding are removed and the process enormously simplified.

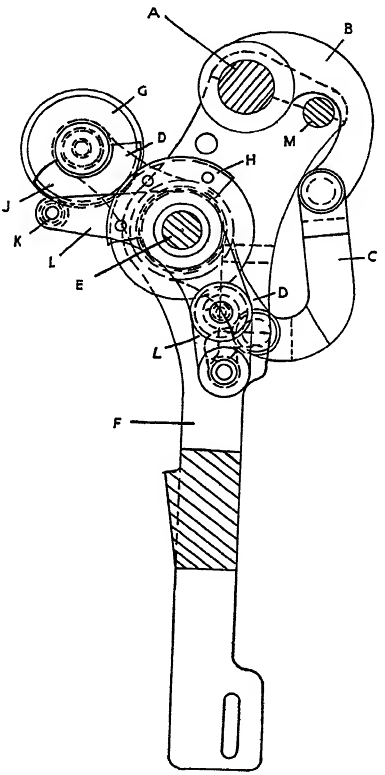


FIG. 37A

The actuating of this cross-winding mechanism is effected by oscillating the winding faller shaft through the boot-leg resting on the block traversing along an undulating rail during the inward run of the carriage. The oscillation of the winding faller shaft *A* (Fig 37A) is

transmitted by a swan-neck lever *B* connecting with the link *C* to a double-ended lever *D* loosely pivoted on the main shaft *E* carried in the main bracket *F* of the cross-winding mechanism. The double-ended lever *D* carries a loosely pivoted pinion *G* gearing with a fixed pinion *H* on the main bracket *F*. The pinion *G* carries a cam *J* contacting with a bowl *K* on one end of the double-ended lever *L* which is actuated by lever *D*. The other end of lever *L* carries a friction clutch on one part of which is fixed a shaper cam which controls the gradual increase of the traverse as the cop bottom is being formed. In the shaper cam is a stud bowl connected by links to the crosser shaft *M*, which is thus oscillated. This shaft *M* carries sickles bearing a third wire which is disposed beneath the threads and is made to rise and fall four times during the winding on the inward run of the carriage.

At the commencement of a set the traverse is at its shortest, gradually lengthens during the formation of the cop bottom, and afterwards remains practically constant until the completion of the set.

The backing-off and unlocking are effected in the same manner as at present, the third wire being suspended from operation by the action of the friction clutch which is released by means of a lever coming in contact with a block on the floor just prior to the completion of the stretch and the letting on at the beam. These cross-wound cops can be packed and transported without risk of damage—the weaver cannot damage them when pushing the shuttle spindle through. It is also claimed that wastage is reduced to a negligible quantity.

There are many causes of bad spinning at the mule, such as cotton not being good enough for the counts spun, slattered or uneven bobbins, or want of twist in roving, too big a draft in mule rollers, too much gain and drag, knocking out too tightly, etc. There are quite a number of extra motions about a modern spinning mule, especially if it is intended for fine counts. The temperature and humidity of the spinning room must be nicely

adjusted if the best spinning is to be got from the cotton used. About the best temperature for a mule room (Fig. 38) spinning American cotton is 78°, with the wet bulb standing at 66°. This is equal to six grains of water to a cubic foot of air. The high temperature softens the waxy coating of the fibres, which, when in a cold state, are hard and congealed, interfering with good spinning. All new mills are fitted with humidifying and ventilating appliances. Not only do these appliances humidify the air, but they purify it from soot, thus keeping the cops clean. They also improve the health conditions of the workpeople.

In spinning the finer and better qualities of yarn there are several extra processes. The sliver in this case would be taken from the card, and passed through one passage of the draw frames to level the sliver up somewhat. The slivers are next taken to a sliver lap machine, which doubles a number of the slivers together and makes a lap about 10½ in. wide. The laps are taken to a ribbon lap machine, which draws them, then doubles them at the front of the machine, and makes a lap ready for the combs. The object of both these machines is to make a lap uniform and homogeneous yard per yard, so that the comber can perform its duties better. These ribbon laps are taken to the comber, which remove all fibres below a certain length, and cleans the cotton from the very fine impurities which cannot be got out in carding.

It is now becoming the practice to comb card strips. The old style of comber could only satisfactorily comb long fibre, but of recent years combers suitable for combing short-stapled cottons have been invented. These combers have encouraged many people to comb their card cylinder and flat strips, with very satisfactory results.

Doubling.

The doubling of yarns has developed during the past few years to such a remarkable extent that a new trade

By courtesy of *"The Illustrated London News"*

FIG. 38. MULE-SPINNING ROOM—ELECTRIC DRIVE

has been created. The doubler produces a very large variety of yarns for all purposes, and his list includes hosiery yarns, conveyor and belting yarns, cable yarns, fish-net yarns, and heavy yarns for sail-cloth. He uses all counts and qualities, from the coarsest waste yarns to the finest combed yarns.

The object of doubling consists in obtaining some special result that cannot be produced in a spun single yarn. It may be strength, elasticity, compactness, lustre, or some special type such as spiral, corkscrew, crepe, cylindrical, gimp, curl, grandrelle, etc.

The operation of doubling consists in drawing threads, either singly or two or more from cops or bobbins, twisting them, and winding them on to a bobbin or into a cop.

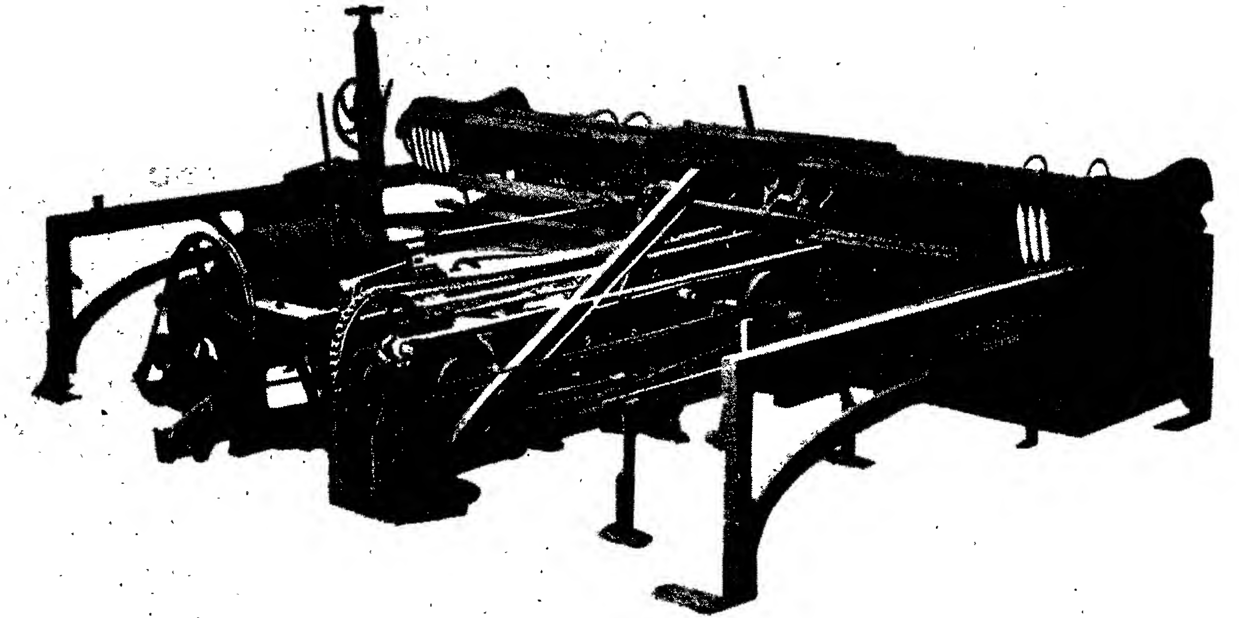
Yarns may be doubled on the continuous or intermittent principle, and either "dry" or "wet." In wet doubling the yarns are moistened with water before being twisted, which makes them more yielding to the twisting, and thus produce a more compact and solid thread as well as a more smooth yarn by the better incorporation of loose fibres.

Intermittent Doubling Machine or Twiner.

The twiner (Fig. 39) is a machine somewhat resembling a mule but has a creel containing cops or cones, each of the cones having two or more ends assembled instead of roving bobbins. There are no drawing rollers. The process of doubling consists in taking single threads from the cops and doubling and twisting them, again forming cops.

There are two kinds of twiners in general use, known respectively as the "English" and "French" systems. In the English type the spindle rails remain stationary, and the creel containing the bobbins or cops moves in and out. In the French type the creel is stationary, and the spindles move in and out. Either machine can be arranged for dry or wet doubling.

Twiner machines are made with a creel, spindles, and fallers, with a headstock in the centre on the principle



By courtesy of *Messrs. Platt Brothers & Co., Ltd.*

FIG. 39. TWINER DOUBLER

of the spinning mule, except that the rollers are not used but a locking motion takes their place.

The creel receives the cops or tubes direct from the spinning frame, and two or more ends are passed to the spindle. If winding bobbins or cones are used the required number of threads have been assembled. The yarn passes over a drag-board covered with flannel and then through a trough if for "wet" doubling. The trough may be dispensed with if "dry" doubling is required, but dry work can also be done through the empty trough. The yarn next passes over a second drag-board, and then between the open fingers of the locking-plate to the spindle.

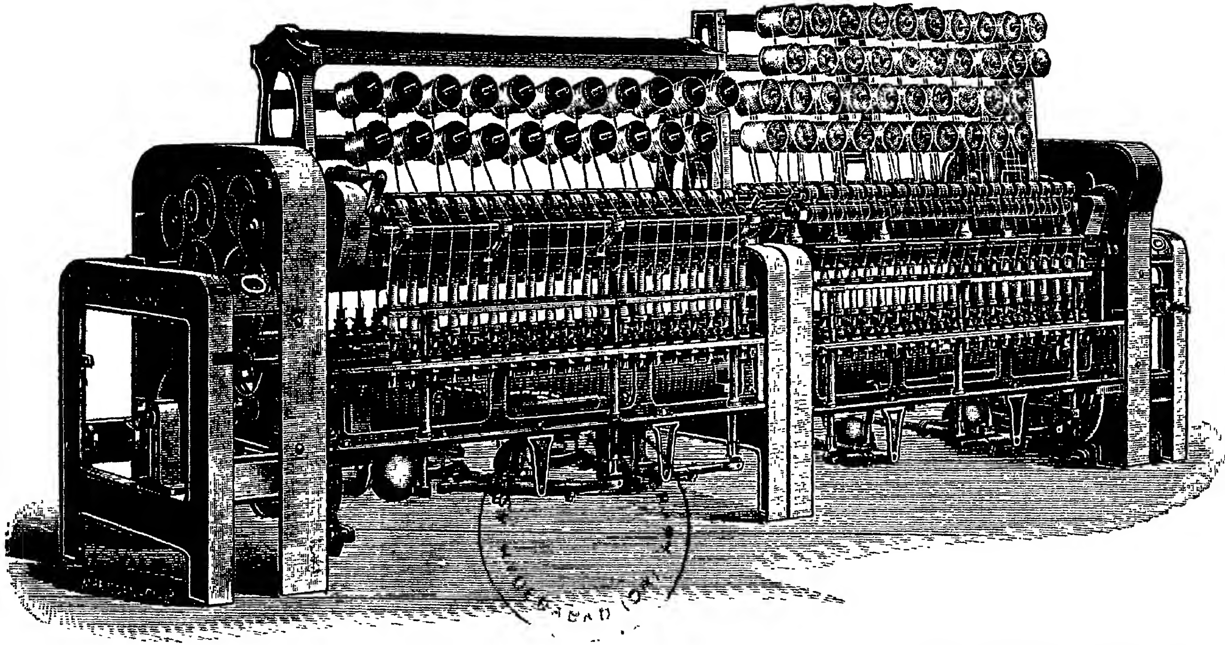
There are five operations done by the twiner, namely—

1. Twisting by the spindles.
2. Drawing-off of the yarn.
3. Backing-off, which unwinds the spiral of yarn from the spindle-blade.
4. Winding-on and taking-in (of the carriage) which forms the cop.
5. The carriage runs in, and the spindles, revolving in the ordinary direction, take up the released yarn which, by means of the faller and counter-faller wires, builds up the cop. The carriage is now "in," and the locking-slides are opened out and allow the yarn to be delivered for a repetition.

In No. 4 movement the single yarn unwinds from the creel as the carriage recedes, and is delivered to the spindle for twisting at a regular rate. On the creel completing its movement from the spindles the locking-slides close and hold the yarn. This is termed the "stretch," and the carriage is then said to be "out." The movements "out" and "in" of the carriage are termed the "draw." The "stretch" may be from 60 to 66 in.

The Ring Doubler.

This machine (Fig. 40) is very similar in design to the ring spinning frame. A creel runs the full length in the

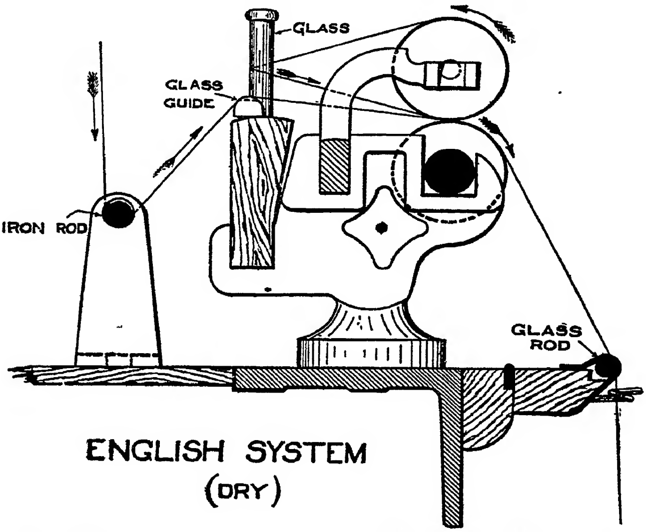


By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 40. RING DOUBLING FRAME (WET)

LEFT: SCOTCH SYSTEM. RIGHT: ENGLISH SYSTEM

centre and is constructed to take cops, bobbins, or cheeses as desired. The delivery rollers are usually $1\frac{3}{4}$ in. diameter for fine, and 2 in. for coarse work. A traverse motion is usually fitted. For dry doubling the bottom rollers are



By courtesy of *Messrs. John Hetherington & Sons, Ltd.*

FIG. 41

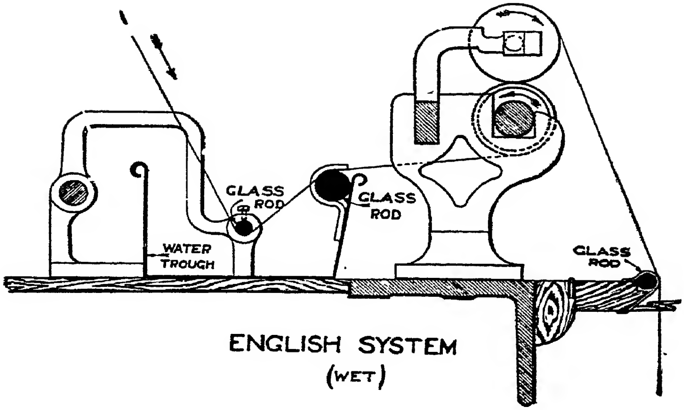
of polished steel, and the top of cast iron, but both top and bottom are brass-covered for wet doubling.

There are three principal methods of doubling known as: (1) English Dry, (2) English Wet, and (3) Scotch Wet.

English Dry System (Fig. 41). The yarn from the creel passes under an iron rod, over a slit glass guide, through the rollers, round the top roller, then bends round a small glass rod, passes again through the rollers and on to the spindles.

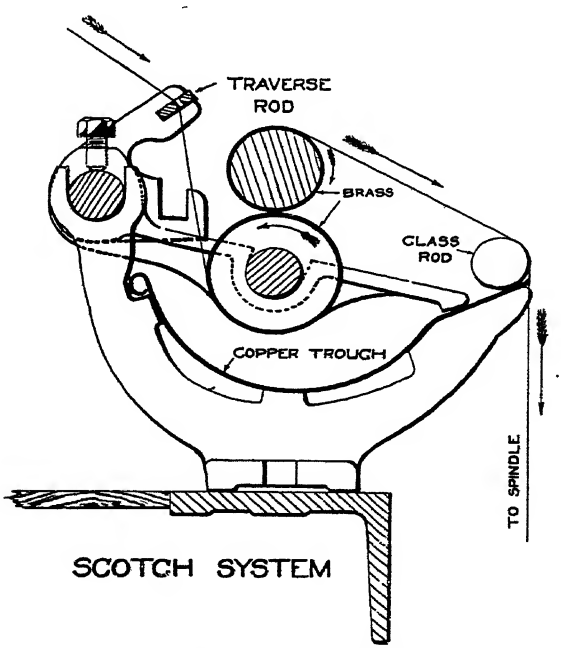
English Wet System (Fig. 41A). The yarn from the creel passes under a glass rod in the water trough, over another glass rod, and on to the delivery rollers.

Scotch Wet System (Fig. 41B). In this machine the trough



By courtesy of *Messrs. John Hetherington & Sons, Ltd.*

FIG. 41A



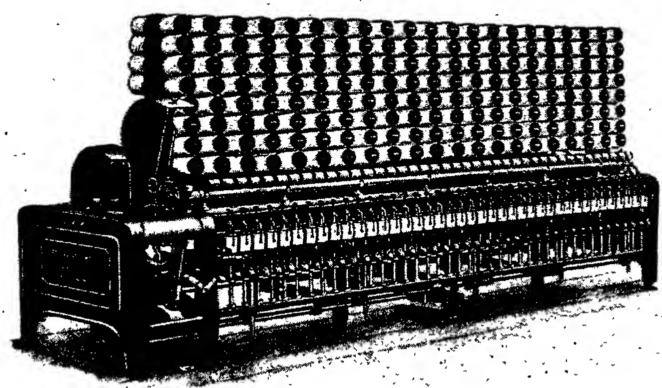
By courtesy of *Messrs. John Hetherington & Sons, Ltd.*

FIG. 41B

is continuous, whereas in the English short troughs are used.

The Flyer Doubler.

This is a machine similar to the ring doubler except that a flyer is used for winding the yarn on to the bobbin instead of a ring and traveller. This type of doubler is



By courtesy of *Messrs. Platt Brothers & Co., Ltd.*

FIG. 42. FLYER DOUBLER

used for heavy yarns such as those for cabling, or tyre cloths (see Fig. 42).

Fancy Doubled Yarns.

The following list gives the most important of the fancy yarns that are made by doubling.

Chain or Diamond Yarn. A fancy doubled yarn composed of three threads. A thick, soft spun thread is twisted with another thread of finer counts, and this doubled yarn is twisted in the reverse direction with a third and finer thread.

Slub Yarns. A cotton thread, which has at intervals

soft, thick places termed slub, flake, or raised part, is twisted with another much finer thread.

Cord Yarns. Two, four, or up to twenty or more single cotton threads are run together without twisting, and a silk or other fancy thread is twined round this cotton core so closely that the cotton is entirely hidden.

Corkscrew Yarn. Two yarns of different counts are twisted together, and each yarn is delivered at a different rate causing the peculiar corkscrew effect.

Crepe Yarns. Very hard, twisted single yarns are doubled together in from four to nine folds.

Curl Yarns. A form of loop yarn made by doubling a coarse yarn round a fine ground thread. The loops are made at one process and then this yarn is twisted with the other. Also called *loop yarn.*

Heald Yarns. Made from super Egyptian cotton, and from six to twenty singles are doubled together.

Knop Yarns. Consist of a doubled thread upon which a knop or bunch is made by one thread winding round the ground thread many more times than the normal. Also called *spot, node, bourette,* or *bead* yarn.

Sewing Threads. Doubled Egyptian or Sea Island cotton yarns. The ordinary quality is three-fold and best quality six-fold or six-cord.

Voile Yarns. Very evenly spun, hard twisted singles are doubled.

Venetian Yarn. Usually is a 2/80's gassed yarn of rather hard twist.

Gassing.

In the process of gassing, the yarn is rapidly passed through a hot flame at a speed so regulated that the loose fibres are burnt off. All cotton yarns contain many projecting ends of fibre, and these fibres add weight but do not add to the strength. During gassing these fibres are burnt off and the yarn made lighter in weight but no weaker. There is a slight discoloration, but this is not considered a defect unless excessive, striped, or streaky.

There are several types of machines in use, and in most of them the yarn passes once only through a powerful flame instead of several times through a small flame as was done in the earlier machines. Fig. 43 illustrates a machine that has ventilating arrangements as a protection for the operatives.

High Drafting.

The meaning of drafting is the drawing out or attenuating of the cotton in such a manner as to produce a yarn to a required fineness, and as uniform in weight and thickness from start to finish as it is possible to make it. High drafting has, as its principal object, the controlling of the bulk of the fibres during the drawing-out operation, and thus the achievement of a much higher draft than is usual.

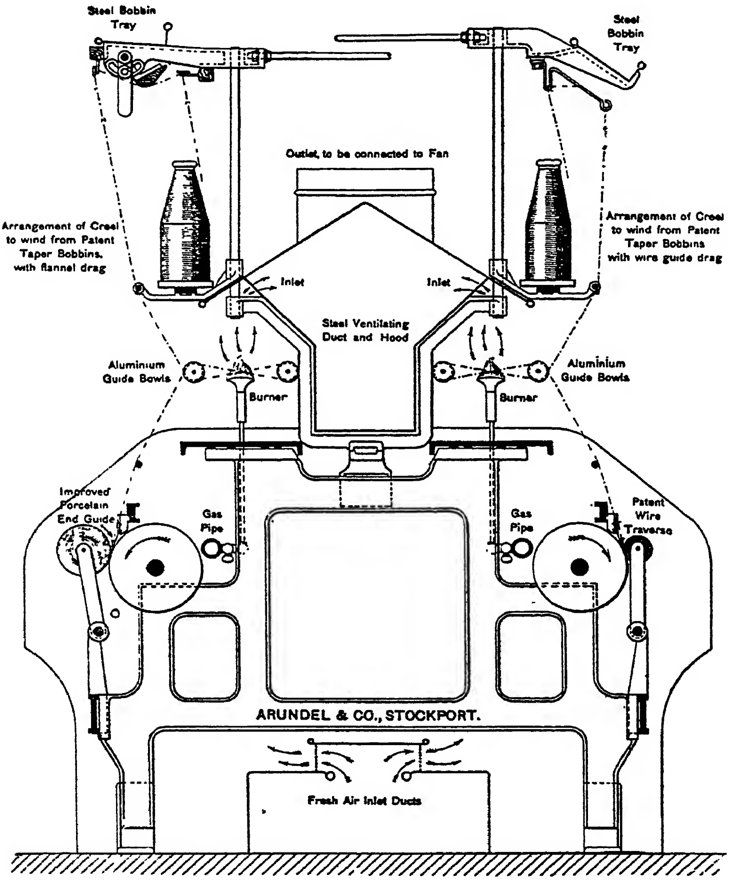
The principle of high drafting has been the study of the machinery makers for many years, and particularly since the invention of the Casablancas process, and to-day there are many systems in use.

By the Casablancas system yarn is spun by taking the material from the intermediate bobbins instead of from the roving frame, thus discarding the roving frames with a corresponding saving in wages. This means that, as the drafts which can be successfully performed with the Casablancas system are usually several times higher than those with the ordinary system, it is possible to dispense with a number of fly or speed frames.

Its advantages are improved quality of yarn, less creeling because the ends do not break so frequently, less piecings of the yarn, thus giving more perfect cloth, and the yarn is increased in strength. Also, it is possible to spin higher counts from a given cotton than with the ordinary system, as, for instance, if 30's is spun from a 1 in. staple cotton on the ordinary machines, the Casablancas method will give 34's to 38's.

As shown in Fig. 44 the apparatus consists essentially of two endless bands of leather between which the roving

is held and carried forward, a cradle or cage which guides the bands and rests on the middle rollers, and a two-armed

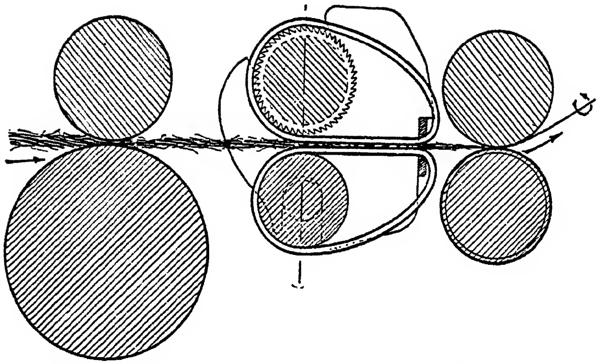


By courtesy of *Messrs. Arundel & Co.*

FIG. 43. GASSING FRAME—HORIZONTAL BURNER

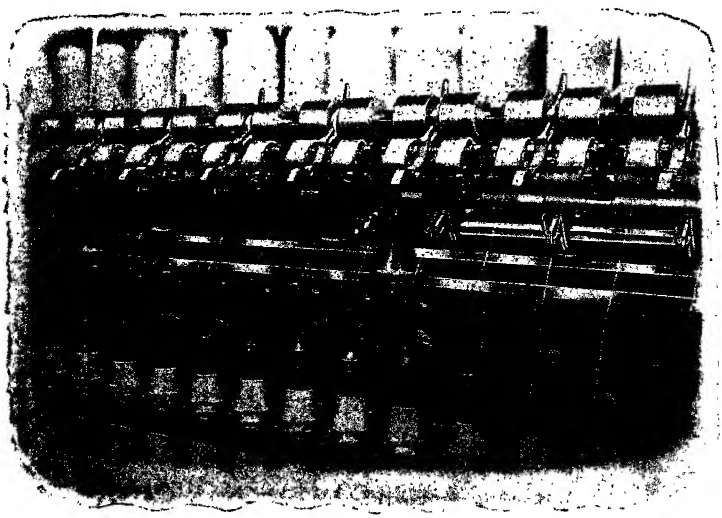
part called the tensor, which holds the bands from inside and at the same time gives stability and exactness to the distance separating the front rollers from the delivery nip of the leather bands.

The back and front rollers of the ordinary machine are



By courtesy of *The Casablancas High Draft Co., Ltd.*

FIG. 44. THE CASABLANCAS HIGH DRAFT SYSTEM, SHOWING ROVING PASSING BETWEEN LEATHER BANDS



By courtesy of *The Casablancas High Draft Co., Ltd.*

FIG. 45. A RING FRAME FITTED WITH THE CASABLANCAS SYSTEM

not altered, but the bottom middle rollers are replaced by others that are specially fluted so that they draw the bottom bands along with the least effort. The top middle rollers are altered in order to fit into the cradle; the upper leather bands move by contact with the lower ones. A saddle imposes pressure on the middle top roller either by dead-weights or lever-weights, thus pressing the two bands together where they pass between the nip of the middle pair of rollers. Fig. 45 shows a ring frame fitted with the Casablancas system.

CHAPTER IV

WINDING, WARPING, AND WEAVING

THE cotton-manufacturing industry of this kingdom, producing plain and artistic cloths in many varieties for all the home markets and distributing centres abroad, constitutes one of the great factors in our industrial and commercial greatness. Were we to seek for evidences of wonderful natural gifts and great genius, we should find them in an eminent degree in the evolution of the productive arts. One has only to compare the perfection of the system of cloth production in the present day with the primitive forms of olden times to realize how wonderfully mind has conquered matter, and how cleverly it has brought scientific exactitude and artistic merit to bear in all the minutiae of textile work.

At the British Textile Exhibition held at the White City, London, was staged the most wonderful display of British fabrics that has ever been seen, and the many thousands of different styles gave a remarkable picture of the development in textile arts during the past few years. These great developments show that Art has become more and more the handmaiden of industry.

The cotton-weaving districts of England are principally centred in North and North-east Lancashire, where the humid climate is an advantage of inestimable value to cloth production. There is also weaving in the Bolton, Manchester, Ashton-under-Lyne, Stockport, and other South Lancashire districts, principally attached in the latter places to the spinning mills. In towns like Preston, Blackburn, and Darwen, too, many firms both spin and manufacture. In Yorkshire there is cotton weaving in the district of Todmorden; and in the Scotch counties of Ayr, Renfrew, and Lanark weaving has in recent years increased in substantial measure. From the domestic

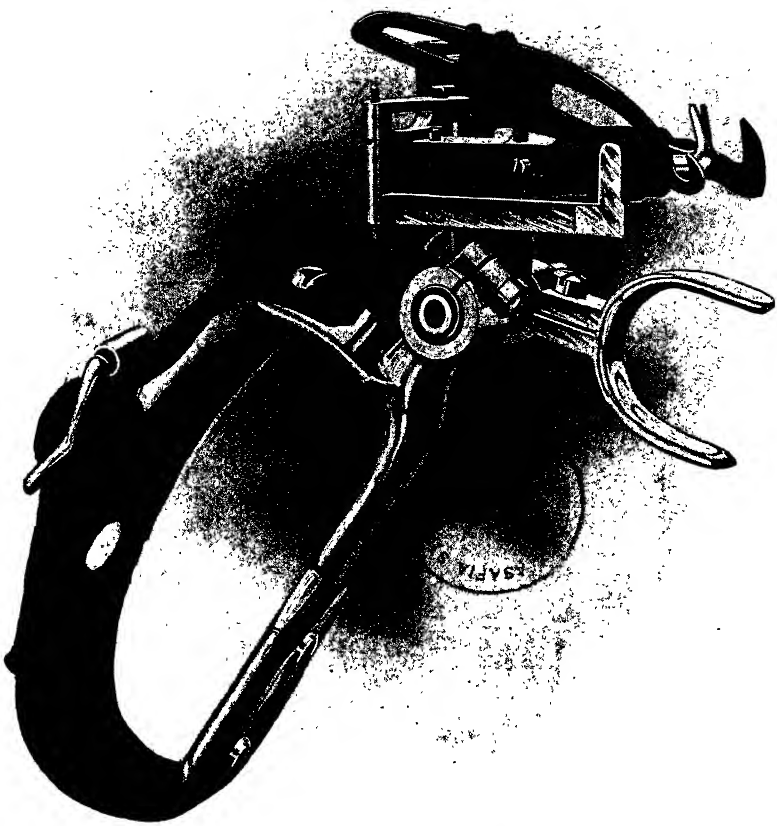
production of spinning and weaving there emerged the factory system, and to-day there are in Lancashire alone 1,800 firms controlling 58 million spindles and 750,000 looms. The looms are distributed as follows—

Burnley and district	101,000
Blackburn and district	93,000
Nelson and district	55,000
Preston and district	68,000
Darwen and district	38,000
Accrington and district	38,000
Chorley and district	27,000
Colne and district	26,000
Bolton and district	26,000
Manchester and district	22,000

There are also thirty districts with from 5,000 up to 20,000 looms.

In describing the process of cotton manufacture we begin with the yarn as purchased from the cotton spinner and delivered at the weaving sheds. This is in various forms, such as cops, hanks, ball warps, and beam warps. The greatest bulk of grey weft yarn is received in the cop, but when required to be bleached or dyed it is usually obtained in the hank. Cop yarn is sometimes reeled into hanks, and then bleached or dyed and wound on to weaver's bobbins; or it may be dyed in the cop state, or wound on to weaver's bobbins direct.

The manufacturing processes pursued in the weaving sheds consist (1) of winding from the cop to the bobbin, (2) of warping or beaming, (3) of sizing, (4) of looming, and (5) of weaving. The yarn, as it comes from the spinning mills, is of two distinct series of threads—twist and weft. The twist forms the threads which run from end to end of the cloth, and is called the warp. The weft threads, called "picks" of weft, traverse from side to side to the selvedges (self edges) of the cloth, and are sometimes called "woof" or "filling." Twist yarn, having to bear a greater strain in the course of manufacturing, is stronger than the weft. The first process, after spinning, is that of winding. The object of this is to place a suitable length of yarn on the spool or bobbin. This bobbin is



By courtesy of *Messrs. Barber & Colman, Ltd.*

FIG. 46. BARBER KNOTTER

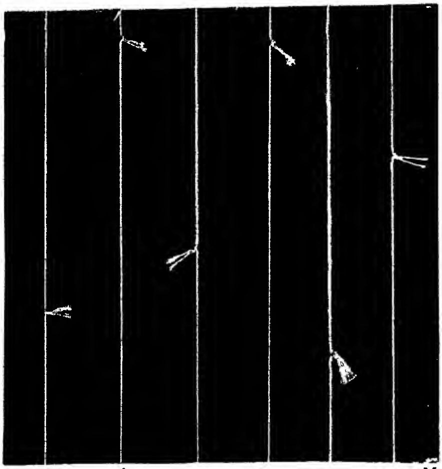
usually made of wood about one inch in diameter, with a flange at each end of about 4 in. diameter, the distance between the flanges being about $4\frac{1}{2}$ in. The weight of yarn which can be placed on one of these bobbins is approximately three-quarters of a pound. In yarn of average or medium thickness the length would be about 27,000 yd. The operation of winding is simple, and has little or no effect upon the material which is being used. The work of the winder is light and is quickly learned by girls or women, who earn on an average about 32s. a week. The usual cop winding machine (Fig. 49) will have one bobbin upon each spindle and about thirty of these spindles constitute the work of one winder. The work of the winder consists in replenishing the yarn and piecing up broken threads. It is essential that in piecing the thread the knot should be neatly made and the ends broken off short. A very ingenious apparatus, called the Barber knotter (Fig. 46), has been devised by an American inventor. This is a small machine strapped on to the hand of the winder. The broken threads are placed in position for the repair; a lever is moved by the thumb and the knot is instantly made and the ends clipped quite close. It is claimed that this enables the operative to attend to more spindles, and that the knot is neater and better made, which is a great advantage in the subsequent processes. Fig. 47 illustrates knots as tied by the appliance.

An important part of a winding machine is the guider which is used to build up a bobbin, and also should clear the yarn of specks, seed, and other impurities left in, as well as detect thick and thin places.

Actually, the winding of yarn is simply the operation of changing its make-up from one form into some other form that may be easier of handling in some subsequent process.

To-day it is seldom that yarn as received from the spinner is not rewound, as manufacturers have realized that better results are obtained. Weft also is being rewound to ensure that all weak places are removed.

The advantages of proper winding appear to have been first demonstrated about 1891, when an Englishman, Mr. J. R. Leeson, designed and constructed winding machines on scientific lines, and since then high-grade machines have been developed for both warp and weft winding. Especially in weft winding has there been rapid progress, and it is now recognized that rewound weft produces



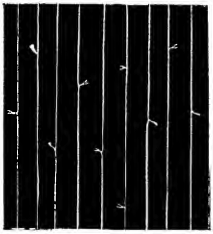


FIG. 47. KNOTS AS TIED BY THE BARBER KNOTTER

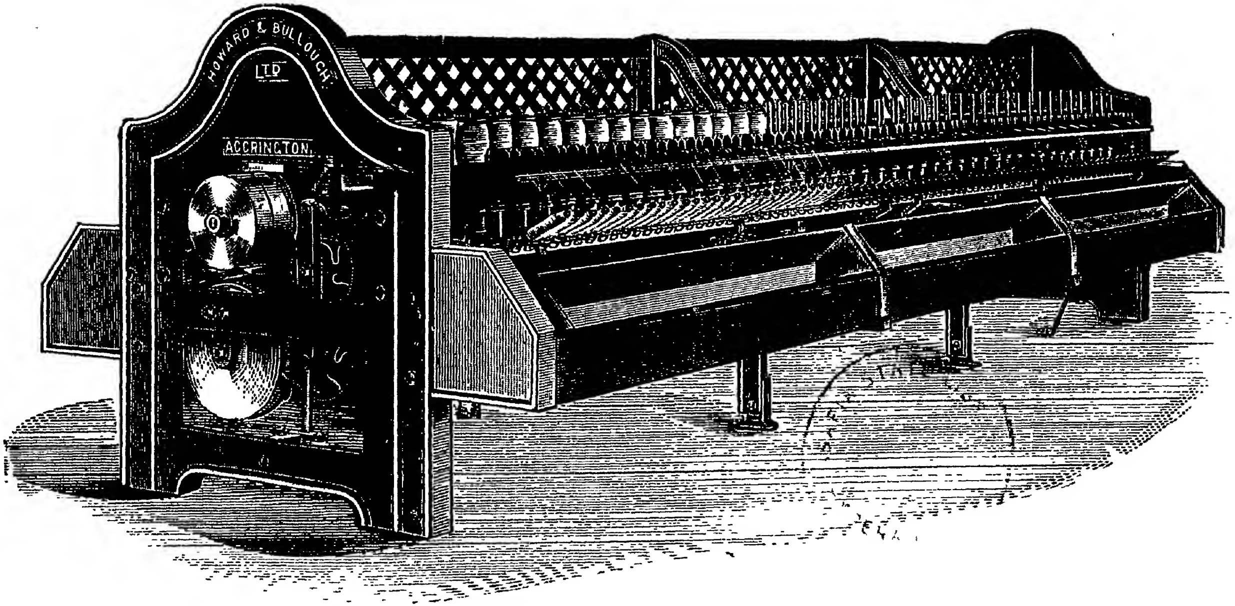
By courtesy of *Messrs. Barber & Colman, Ltd.*

better cloth, reduces waste to a minimum, increases the loom's production, and the weaver is able to attend to weaving with greater ease.

Fig. 48 shows the machine used for winding yarn from mule cops or ring bobbins on to warper's bobbins, and Fig. 50 illustrates a view of the winding from bobbins to beams.

Winding Weft.

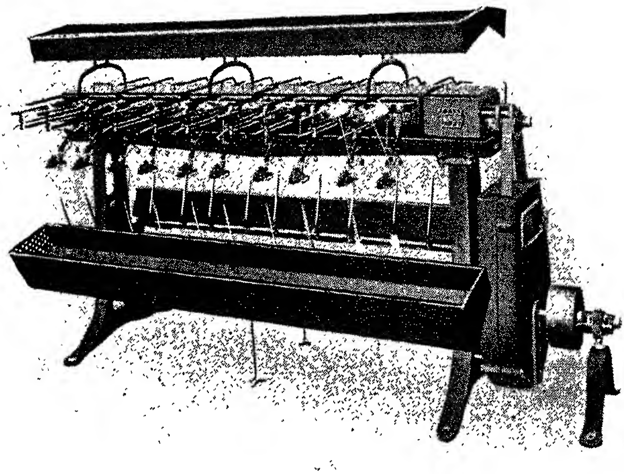
The introduction of artificial silk and automatic looms into weaving mills has exercised a great influence in the development of modern methods of pirn winding. The "Leesona" machine (Fig. 49) is built to make a pirn of weft so perfect that it will operate from start to finish without



By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 48. BOBBIN WINDING FRAME—FROM MULE COPS OR RING BOBBINS TO WARPER'S BOBBINS

breaking. During the winding process the machine removes all weak places and other faults. It is adapted for all varieties of yarns, and is especially suitable for winding such difficult yarns as artificial silk, and polished, mercerized, and voile yarns, which, because of their wiry,



By courtesy of *The Universal Winding Co.*

FIG. 49. "LEESONA" NO. 90 WINDING MACHINE

springy, or glossy nature, are very liable to slip off the pirn in coils or rings.

When a cop is placed directly into the shuttle from the spinner the yarn has all the inherent defects set up during spinning, with the result that owing to weak places, slubs, etc., the weft often breaks before the cop is exhausted. Also there is considerable waste from skewered cops, etc. When the weft is rewound on such a machine as Fig. 49 the weavers are provided with perfectly wound pirns.

The machine consists of 20 spindles, assembled in five sections of 4 spindles each, making 10 spindles on each side. The driving shaft extends through the entire machine, and imparts rotation to the spindles by means of

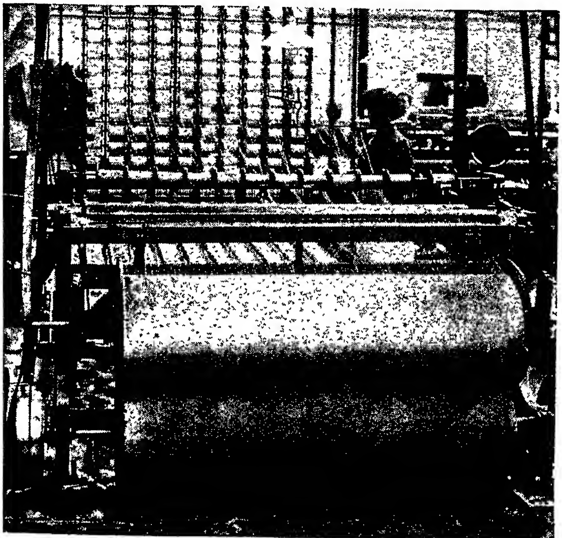
pairs of spiral gears. The driving gear is contained in a gainer case—in the gainer case the driving shaft is geared to the cam which operates the rise and fall of a rocker shaft extending the length of the machine. This rocker shaft, by means of a lever, conveys to the yarn traverse bar a reciprocating motion so arranged that seven different lengths of traverse can be obtained. A train of gears in the head end of the machine controls the wind, or ratio of traverse to spindle revolutions; thus, an equal number of turns or winds is imparted to the yarn from the nose to the heel of the chase, and *vice versa*. Seven turns are generally used, but the number can be readily changed to suit different types of weft used.

Warping.

The second process is warping or beaming, and here we have three distinct methods which are made use of according to the kind of cloth which the manufacturer is about to make. The methods are termed beam, mill, and sectional warping.

In beam warping a number of the bobbins which have been filled on the winding frame are placed in a creel or frame, the usual number ranging from 500 to 600. The threads from the bobbins are taken separately, passed through the machine, and made fast to the warper's beam. This beam is of solid wood, about 5 in. in diameter and 60 in. long, with an iron flange upon each end of a diameter of 21 in., or thereabouts. This beam rests upon a revolving cylinder of wood which imparts the motive power to the beam, and gradually draws round it the threads from the bobbins. The amount of yarn which one of these beams will hold is about 300 lb., and a common length in medium counts would be 500 threads each 20,000 yd. long. The principal device in this machine is the automatic stop motion, bringing the machine to a stop the instant a thread breaks. The operation is simple. A piece of bent wire about 2 in. long, in the form of the letter "U" inverted,

hangs upon each thread. This is technically termed the drop pin. Should the thread break, the drop pin falls down and is caught between two revolving rollers which are in close contact with each other. As the pin passes between these rollers it necessarily presses them an infinitesimal distance apart; but this distance, though

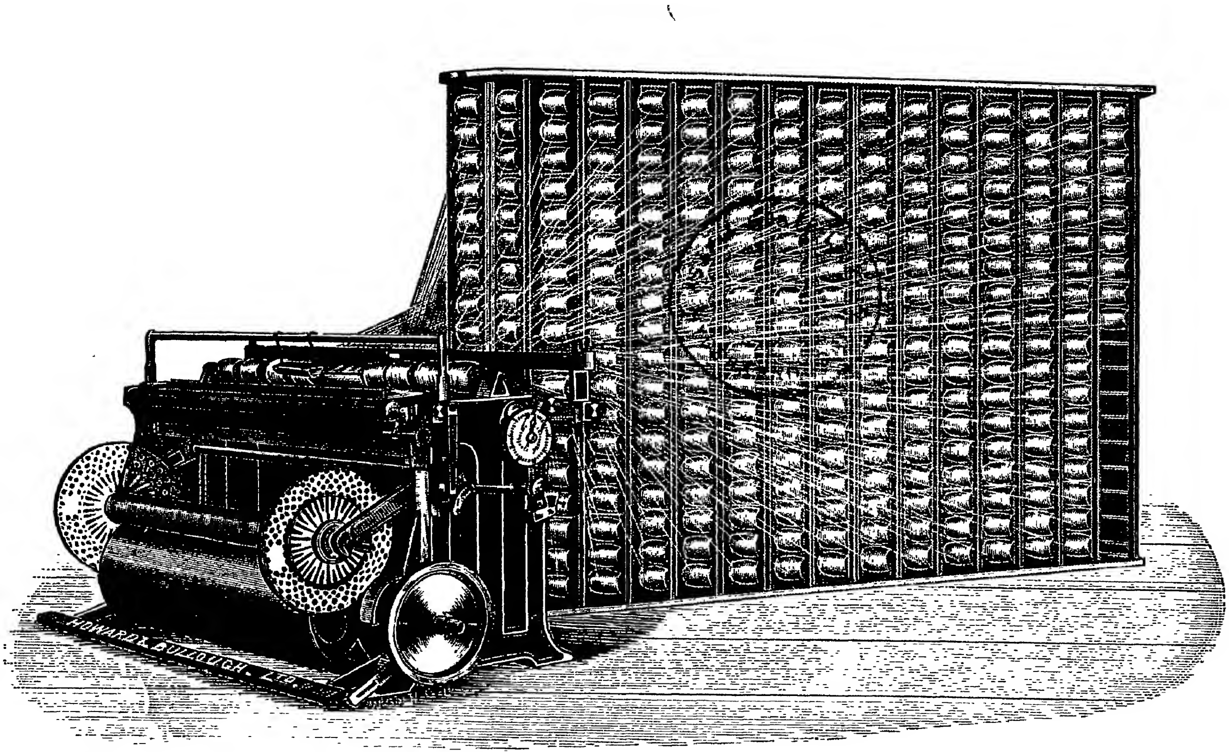


By courtesy of *"The Illustrated London News"*

FIG. 50. WARPING MACHINE

exceedingly small, is sufficient to relieve a delicately adjusted lever which brings the machine to a stop immediately. The work of warping is congenial employment for women; the wages earned are fairly good, amounting to about 32s. to 35s. per week on the average.

Beam warping is the system generally used for grey cloth, and gives very good results. When the slasher sizing machine was first introduced it became a necessity that a machine of this kind should also be used, and thus the inventor of the sizing machine invented the first beam warper.



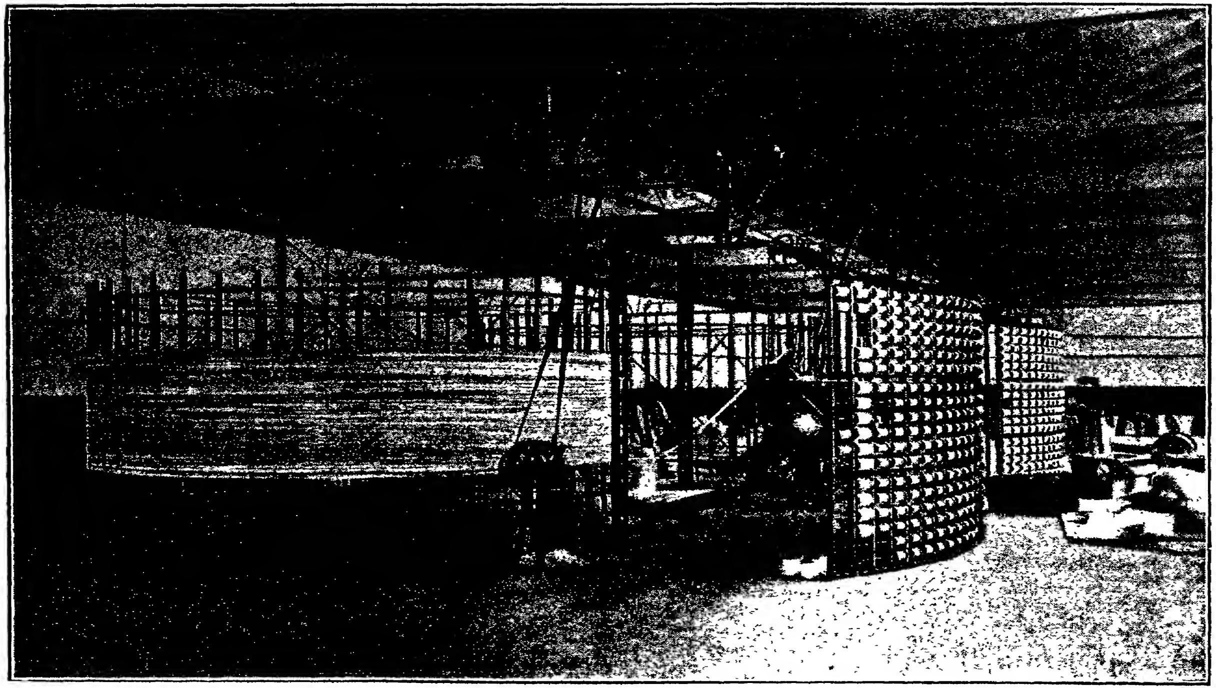
By courtesy of *Messrs. Howard & Bullough, Ltd.*

FIG. 51. BEAMING MACHINE, WITH SELF-STOPPING MOTION

In mill warping the bobbins are also placed in a frame or creel, but the number is limited to about 200. The threads are then gathered separately from the bobbins and formed into a rope. This rope is made fast to a peg upon a large upright wooden cylinder or reel. The size of this cylinder or reel varies considerably, but a common size would be one of 8 to 10 ft. high, and 12 yd. in circumference. This large cylinder is made to revolve in either direction, backwards or forwards, as required. After the rope of threads has been made fast to it the movement of the cylinder commences and, as it revolves, the rope, by suitable mechanism, is made to traverse from the bottom of the cylinder to the top, thus avoiding the whole of the yarn being run in one place on the cylinder. After the rope has got to the top of the machine the direction in which the cylinder is running can, if required, be reversed, and the rope begins to descend. By this means any suitable number of threads and length may be warped. For example, if a warp was required 360 threads, 500 yd. long, 180 bobbins would be put into the creel, and 500 yd. would be run on to the cylinder. Then the motion would be reversed, and similar ends and length would be run on to the top of the first, thus completing the warp required. This rope, or warp, as it is called, is then drawn from the machine and made into a ball for delivery to the dyer and sizer.

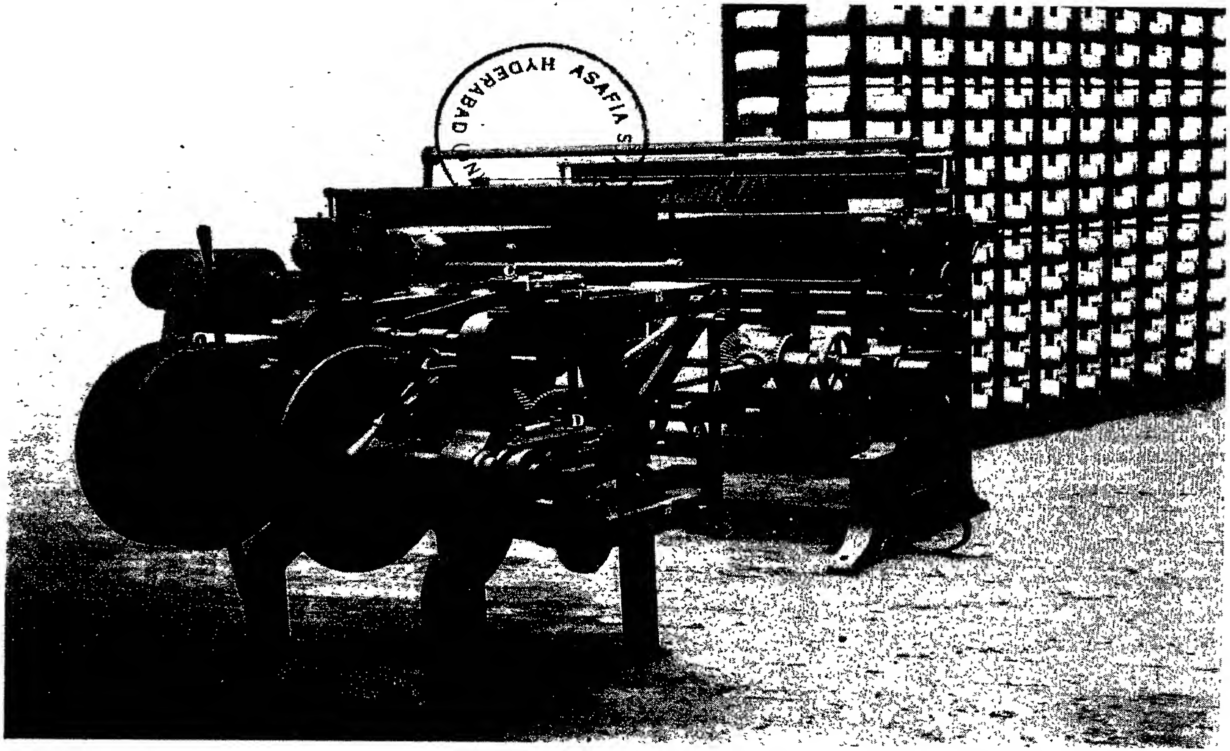
The warping mill (Fig. 52) is perhaps the oldest method of preparing warps used to-day, and often termed a machine of the past, but it is still largely used in Lancashire and Yorkshire. Manufacturers who use this system say they cannot get any other machine to do the work better or cheaper, and claim as advantages that there are very few knots in a warp, and that, when made, the warps can be sized or dyed at a less cost than with other systems.

The sectional warper is so named because one beam contains part only of a complete warp, and there may be 6, 8, or 10 beams in a set. It is imperative that the threads on each beam should be of one length, as the length of the



By courtesy of *Messrs. Thos. Holt, Ltd.*

FIG. 52. WARPING MILL



By courtesy of Messrs. Butterworth & Dickinson, Ltd.

shortest thread gives the length of the warp and the remainders are waste. To ensure equal length on each beam a reliable measuring motion is used. Fig. 51 shows one machine.

In the sectional warper (Fig. 53) the yarn used is such as has been previously sized, or yarn which does not require to be sized. This process of sizing will be explained later. Here, again, bobbins are placed in a creel, and are drawn off on to a *cheese*. This cheese is a block of wood a few inches in diameter and length, and forms practically a miniature of the beam described in beam warping, but without the flanges. After a suitable length has been placed upon this cheese others of a similar character are formed. The whole of the cheeses are then placed upon a shaft and run off on to the weaver's beam. A cheese, therefore, really forms a transverse section of the weaver's beam. As previously indicated, where beam warping is used the cloth is usually made in the "grey" state, that is, it does not contain threads which have been dyed. If the manufacturer is one who makes coloured goods, or cloth composed of coloured threads, either mill or sectional warping will be the one which he will adopt. Manufacturers differ in their opinion as to the relative value of mill and sectional warping.

In sectional warping the operative must be careful that each section is of the same length; say the first section is 900 yd., then all must be the same; if not, there will be excessive waste. All the sections require to be of the same diameter to ensure a level beam.

The efficient preparation of warps for the loom is a necessity if perfect cloth at the minimum cost is to be produced. The arrangement of the several departments should be as progressive as possible, and unnecessary handling of the yarn and bobbins avoided. In the winding room, for instance, the yarn store should be near the winder, and yarn should always be ready for use. The bobbins also should be handy. Great care should be taken that the bobbins do not get mixed.

Sizing.

The process following warping is that of sizing, which consists in applying a paste to the yarn in order to strengthen it and enable it to withstand the friction to which it is subjected in the loom, where there is considerable tension on the threads. For certain classes of goods sizing has additional uses, first to add weight to the cloth and, secondly, to give the cloth a "feel" or "handle" which enhances its market value. The necessity of sizing was realized in the old hand-loom days when it was done in primitive fashion. The art of perfect sizing is obviously one of supreme importance.

Sizing has been practised ever since short cotton fibres were used. The Indian natives sized both warp and weft, but we only size warp. In the hand-loom days the weaver who sized his yarn was admittedly a clever worker, for considerable skill was required and the work was long and tedious. The warp was put in the loom unsized and the weaver sized it stretch by stretch. He first sized one stretch, and then it was woven into cloth; he sized another and this was woven, and so on till the warp was finished. The yarn could not be woven while wet; it had to be dried. A heating iron of special form was used. Whilst the weaver was putting the size upon the yarn, and brushing it in one direction the iron was being heated to a red heat; then he passed the hot iron under the warp, and by waving a paper fan to and fro over the yarn heated air was made which dried the yarn. He also had to make the piecings of the size of the same colour and thickness, so that they would not be seen in the cloth.

This hand method was continued when the power loom was invented, and because of its difficulties was one of the reasons why Cartwright's loom did not meet with approval. To overcome this prejudice two systems of sizing were soon developed, one known as "sizing" and the other as "dressing." In "sizing" the yarn was made into a ball warp and placed into a pan of water and

boiled; it was then partially dried in the air and put into a tub containing the size. The tub had several holes near the top and one end of the ball of yarn was drawn through one of the holes—as the yarn was drawn through the excess size was squeezed off and part forced into the core of the warp. The warp was then hung upon pegs to dry. All coarse yarns were thus sized, and most fine yarns also, but the fine yarns were "dressed" as well.

Dressing consisted of applying cold paste, by means of a brush, to the yarn in the loom, which pasted down the fibres, and gave the yarn smoothness besides removing all lumps and equally distributing the paste.

All twist which is single must necessarily be sized, but folded yarn will weave without size. A folded yarn is one in which two or more single threads are twisted together rope-like, the threads strengthening each other. This is the kind of yarn referred to in sectional warping, where it was stated that this peculiar process of warping was suitable for yarn which did not require sizing. The paste, or size, which is applied to the yarn, is, in its simplest form, made from some farinaceous substance such as wheaten flour, farina or potato starch, or sago flour. This is boiled in water, and a small quantity of tallow added to it, which keeps the yarn pliable. Japanese wax and paraffin wax are used as softeners in the heavy sizings, and castor oil and glycerine are at times used. The amount of size used varies according to the kind of cloth to be made. It may be as low as 5 or as high as 200 per cent. Those cloths holding above 50 per cent of size are known as heavily sized, and those below that percentage vary from light-sized up to about 20 per cent, to medium-sized up to 50 per cent.

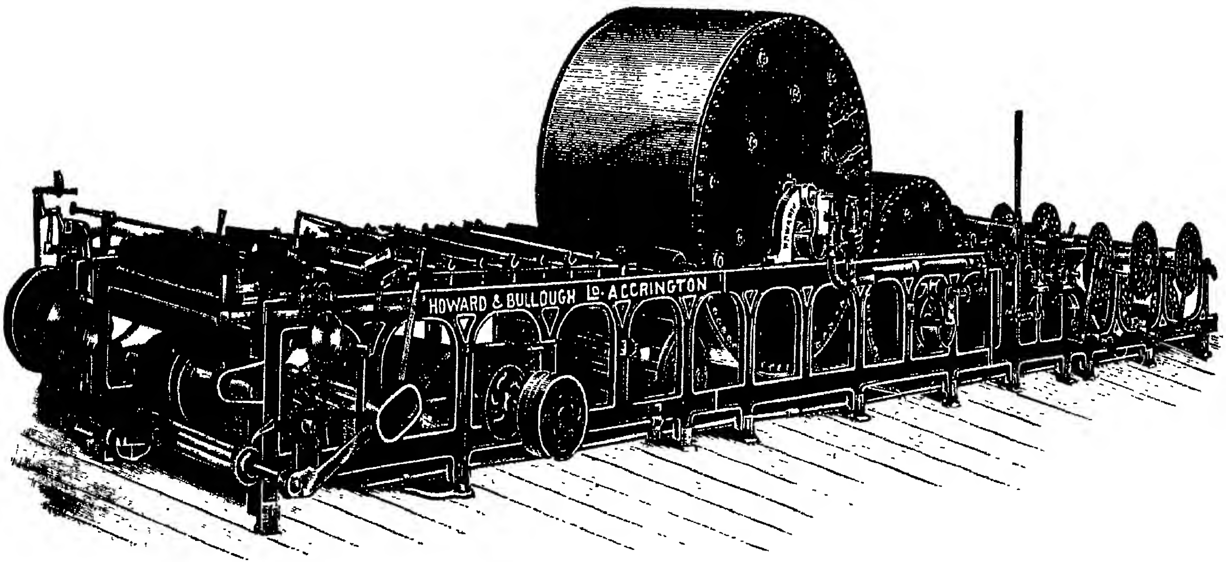
For cloths which require weight added to them other materials are used, such as China clay, chloride of magnesium, chloride of zinc, etc., the latter being a great antiseptic and strong preventive of mildew. The prevention of mildew is of vital importance to the manufacturer, for if the vegetable growth is found to have

developed, owing to sizing defects, after the cloth has reached the distributing centres, the loss falls on the maker. Size is mixed in strong wooden becks, equipped with revolving dashers, or agitators, which keep the mixture stirred up and ensure the blending of the various ingredients. The usual number of becks or tanks is four, each with a pump attachment to send the size mixing, which has to be thoroughly boiled and with no granulation, on to the size box on the slasher frame.

Slasher Sizing.

The slasher sizing machine (Fig. 54) is by far the machine most used. This name was given to it when first introduced because of the large amount of work it did. Every part of the slasher has received the keenest study, and numerous improvements have been made till to-day it is a fairly complicated machine. Its various parts are the creel, size box, drying arrangement, headstock, and the driving and winding appliances, all coupled together (first, the sizing; secondly, the drying; and thirdly, the winding). Sometimes the process is called "taping," a term which was used in the days of the tape frame well on for half a century ago. A piece of cloth usually consists of several thousand threads, and, in order to form these, a number of warper's beams of about 500 ends each are placed behind the sizing machine. The threads from each beam are then gathered together in one compact sheet and run under a roller which is immersed in the boiling size, which impregnates every inch of the fibre which passes into it. Mr. C. P. Brooks admirably illustrates this in his book on *Cotton Manufacturing*.

Supposing a warp is required of 2,480 ends—three beams, each 504, will be taken together with two of 484 each; these are placed in the creel in two levels, and the narrower ones are placed at the back. If they were in front of the broader ones the sheet of warp would overhang the narrow beams. The ends are gathered in one sheet, the layers from the hinder beams passing over the top beams and under the bottom ones, all leaving the creel after



By courtesy of Messrs. Howard & Bullough, Ltd.

FIG. 54. CYLINDER SIZING MACHINE (SLASHER)

passing under the foremost beam and travelling into the sow box. Two contiguous boxes or troughs are used for holding the size—the one farther from the creel, called the size box, receiving the mixture directly from the beck, a regulating valve being fixed on the inlet pipe to prevent the box becoming too full. The sow box is the larger one, and receives the size from an aperture in the bottom of the size box, as well as from a separate pipe. In the bottom of the sow box is fixed a boiling pipe of elliptical form, perforated with small holes, through which steam is forced into the size, causing it to boil, and thus always be in the fittest state for application to the yarn. At about half the height of the box two pairs of rollers are fixed, the back pair having the bottom one of wood, and the top one of iron, covered with flannel and cloth; the front bottom roller, or finisher, is of copper, having resting on it a heavy iron one, likewise covered with several layers of flannel and two of cotton cloth. On the firm and even surface of these rollers depends, to a great extent, the quality of the sizing. Between the wooden roller and the end of the box nearest the creel is a copper immersion roller, its use being to lower or raise the warp in the size by means of a rack and pinion. The warp ends coming up from the beams (Fig. 55) pass under the immersion roller, thus being soaked under the surface of the boiling size, thence between the first and second pairs of rollers—the object of these being to press out all superfluous size and imbed into the thread that which is required. Immersing the thread deeply is advantageous for heavy sizing, although, by simply dipping it, the fluid only attaches itself to the outside of the thread. Better results could be obtained by pressing the yarn whilst under the surface. Unless well boiled, size retains a granular nature, causing faulty cloth; to obviate this, many machinists insert between the size beck and the sizing frame an extra boiling apparatus, so arranged by the intervention of pipes to boil the size under pressure, impinging steam against the particles of size as they enter the box, thus breaking the globules. After boiling thus, the size enters the box in the ordinary way. To lay the fibres on the yarn a few sizers have recourse to revolving brushes acting on the thread directly after passing the finisher roller. These revolve about 700 revolutions per minute, considerably faster than the warp speed. They are considered advisable for fine reeds and fancy goods.

After leaving the rollers the yarn passes over two steam-heated revolving cylinders, of about 7 ft. and 4 ft. diameter respectively, and is then wound on to the weaver's beam in front of the machine. This process of sizing is applied to yarn made on the beam warper. To indicate the weaving lengths the warp is marked by the measuring roller on the sizing frame.

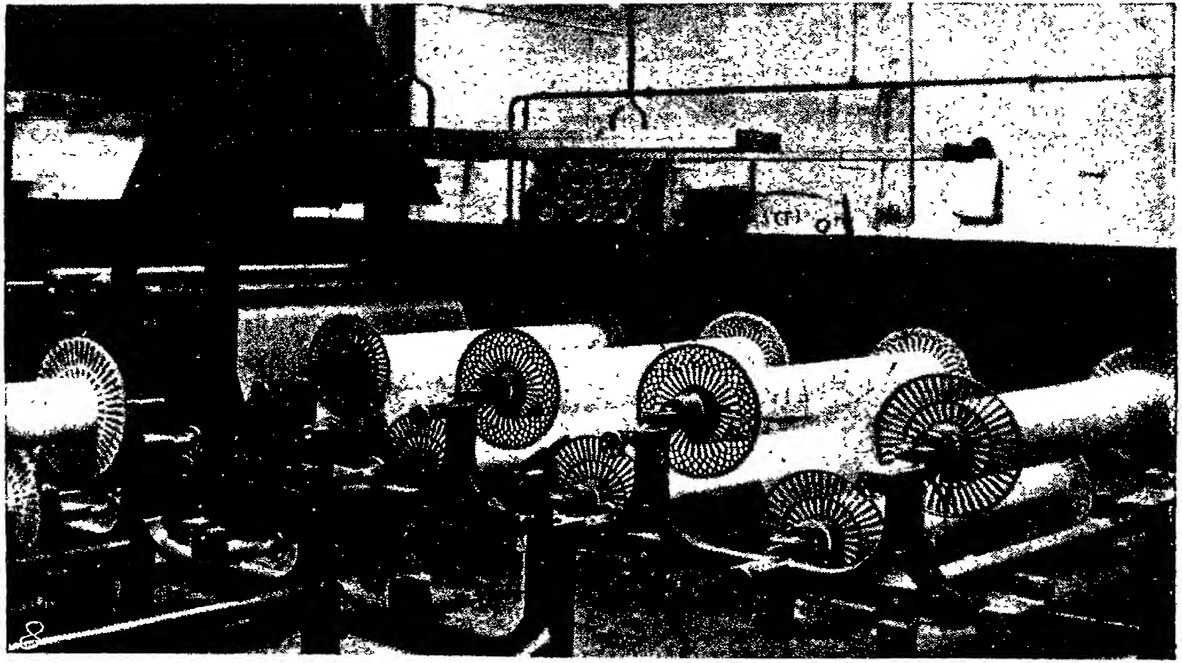


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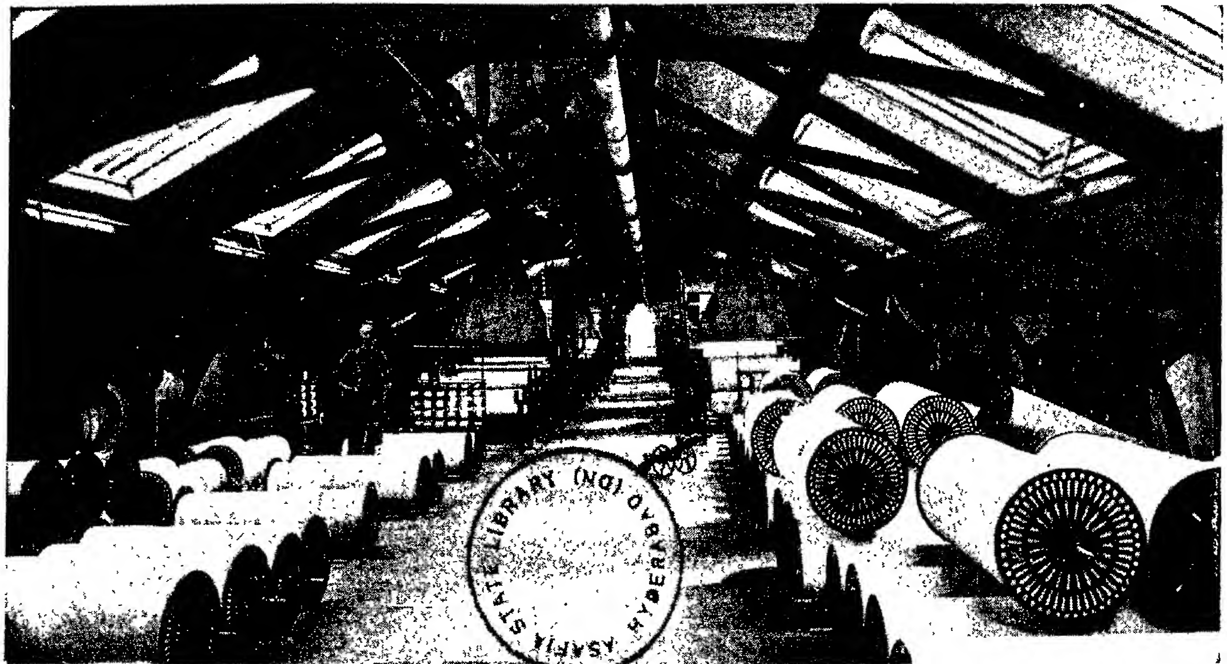
FIG. 55. SIZING MACHINE—CREEL AT BACK OF SLASHER



By courtesy of *"The Illustrated London News"*

FIG. 56. SIZING ROOM, SHOWING TWO SLASHERS

Fig. 56 illustrates a sizing room with two slasher sizing machines at the far end and sets of back beams in front.

Ball Sizing.

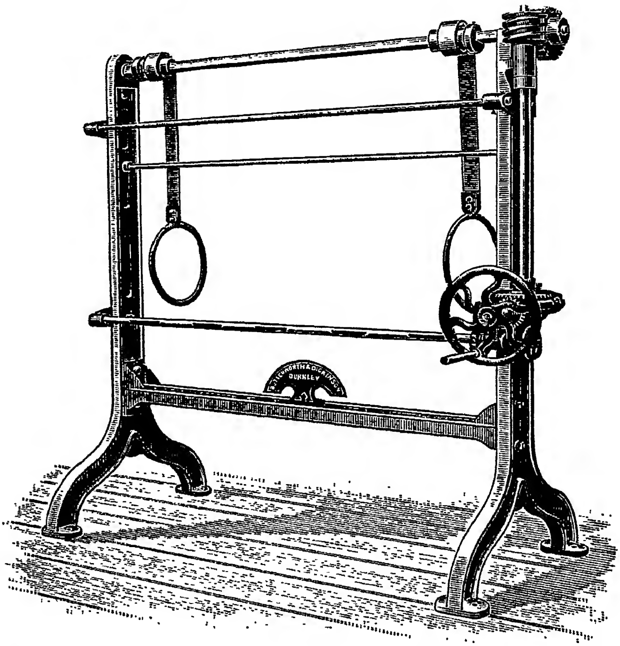
This is the system of sizing that was being developed along with the dressing frame. It has altered very little during recent years. The system consists of three operations, sizing, drying, and reballing, and three separate machines are used. Sometimes the sizing and drying machines are connected, but the reballing machine is separate. The ball warps, made by the mill warper, sectional warper, or beam warper, and afterwards balled, are sized by this method.

This ball form is simply for the convenience of handling. The ball is taken to the sizer and unwound, the rope of yarn is passed through the boiling size, and is afterwards dried on hot cylinders, and the threads spread out and run on to the weaver's beam. The work of sizing is done by men who are well organized as a trade. They are in receipt of good wages, usually about four guineas or more per week.

Looming and Drawing.

The beams holding sized warp, varying from 500 to 1,000 yd. in length, are now taken into the looming room, where the threads of the beam are attached to the healds and reed. The frame for drawing-in (Fig. 57) or looming is a simple one, and consists of an upright skeleton frame fitted with appliances for holding the beam of yarn, the set of healds, and the reed. The operator sits in front of the reed and, selecting threads from the beam, draws them through the healds and the reed. The operator inserts a hooked implement through a dent in the reed, then through the correct heald eye, and his assistant at the back places a thread on the hook which is then drawn to the front. The healds are for the purpose of raising the threads in the loom as required to form the pattern of the cloth. The reed may be described as a

kind of grate or grid, the bars being made of extremely fine wire placed at suitable distances apart in strips of wood, by the aid of machinery. The reed has a three-fold purpose—first, to give support for the shuttle as it



By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

FIG. 57. DRAWING-IN FRAME

passes from side to side of the loom; secondly, to keep the threads of the warp in their proper place in the cloth, and thirdly, to bring up each succeeding line of weft in close contact with the one which preceded it. The loomers and drawers who attach the beams to the healds receive about 60s. per week, and the work is of a light character.

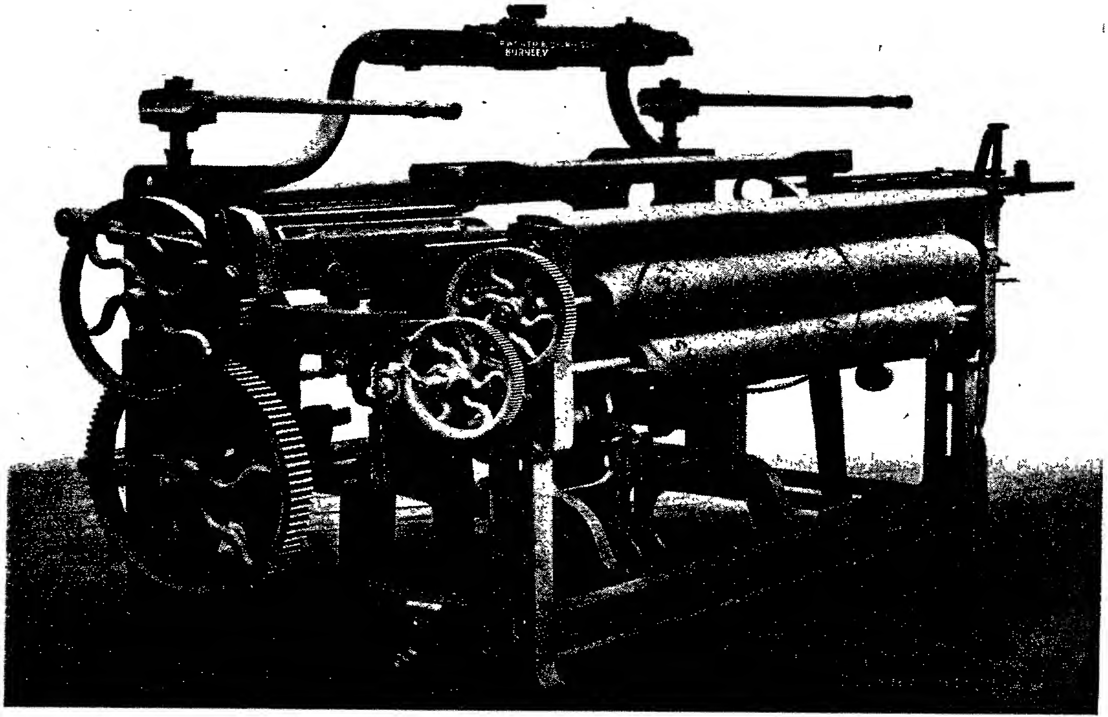
Weaving.

We have now reached the final stage by which the cotton is converted into a woven fabric—that of weaving.

It will be seen how the textile processes are conducted in sequence, with the greatest expedition and economy of labour. The machinery in the various departments is driven by the powerful modern engine. It may be taken that a condensing horizontal engine of 250 indicated horse-power will be required to drive 1,000 looms, the steam being generated in double-flued steel boilers where it not uncommonly attains a pressure of 120 lb. per square inch. The huge development of cotton manufacturing has been one of the industrial phenomena of the past 100 years. It was in 1801 that the first power-loom weaving shed, holding about 200 looms, was built and worked on a successful basis. The great strength of British weaving, as pointed out, resides in North and North-east Lancashire. Here the majority of the sheds are owned by private firms, but a few are owned by companies formed under the Limited Liability Act, which was passed in 1862, and enabled working people to invest their money, with a limit to their liability. The plain loom (Fig. 58) is the foundation of all weaving, the fancies, etc., being developments in mechanism, some of an intricate character. Every manufacturer has his own method of fixing the different motions of the power loom, and in many mills various new ideas are constantly being developed for producing some novelty.

The looms are arranged in rows, back to back, and a weaver usually attends to a set of four. There is at the present time a strong feeling among manufacturers that the weaver should run more than four, and that six or even eight could be efficiently operated by one weaver, who would weave only, as most of the other duties would be attended to by less skilled workers. This, of course, only refers to the standard loom of 45 in. reed space.

The width of cloth varies from about 20 in. to 100 in. (though even this is sometimes exceeded) the average width being about 42 in. We have seen with the completion of the sizing how all is ready for the culminating process. The beam with the healds and reed is taken to



By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

FIG. 58. PLAIN LOOM

the loom, the various parts being fixed in position on the framework. The warp (which is held taut and straight by the taking-up roller in front of the loom) passes over the back rest, under and over lease rods which divide the threads, and then to the healds and reed. The weft is skewered in the shuttle, driven by the picking stick from side to side, and interwoven with the warp, cloth being rapidly made. The various forms of looms, and the appliances for making different patterns and qualities of cloth, are innumerable, and require by themselves many volumes to describe adequately.

There are five principal motions in a loom whether for plain or fancy weaving, and they are—

1. Letting off the warp yarn from the beam.
2. Opening of a shed by lifting up certain threads and leaving others down to allow the shuttle to pass through.
3. The throwing of the shuttle between the two sets of threads, leaving a line of weft in its track.
4. The beating in of the weft up to the fell of the cloth.
5. The taking up of the cloth.

These operations are technically termed "letting off," "shedding," "picking," "beating up," and "taking up."

Letting Off.

The letting off of the warp yarn is simply a tension motion, putting a strain upon the yarn during the whole time of weaving. There is also a strain upon the healds during a rise or a fall to form a shed, which means that inferior yarn does not bear the same amount of weight or strain as good yarn will. A weaver is often tempted to take weight off the warp, if a poor quality, to reduce the number of broken threads.

Letting off is effected in nearly all light looms by the chain, or rope-and-collar friction arrangement. Chains are most durable and are not affected by changes in the weather. When a warp beam is first put in the loom it has the maximum weight, and the weight is gradually reduced as yarn is drawn off; it therefore follows that

weight must be taken off as the beam gets empty, and this should take place regularly as the beam unwinds.

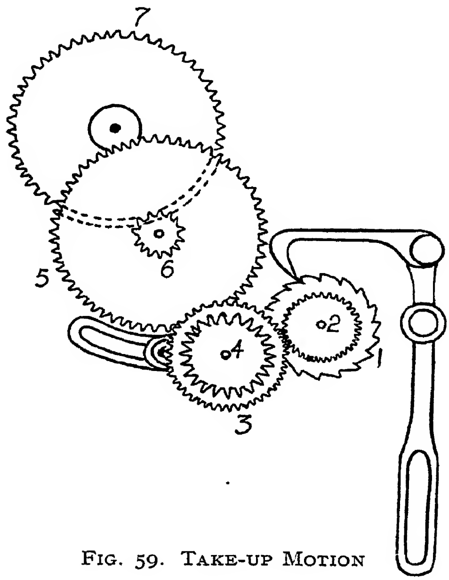


FIG. 59. TAKE-UP MOTION

There are numerous inventions of what are known as "positive" and "negative" let-off motions, but none of them has been adopted to any great extent.

Take-up Motion.

As the cloth is woven it has to be wound on to the cloth or sand roller at the front of the loom. This is done by means of a "take-up" motion, consisting of a train of toothed wheels, which takes up cloth as the sand roller brings it forward. An arrangement of wheels that is largely used in the textile trade is known as "Pickles' motion," Fig. 59. There are seven wheels in this train, the first of which is a ratchet and is actuated by a pawl from the sley, transferring motion to the sand roller

which draws the cloth forward. In the sketch, 1 is the ratchet wheel; on the same stud is mounted the change wheel 2 which drives change wheel 3; at the back of 3 is pinion wheel 4, which gears into carrier wheel 5; at the back of 5 is carrier-wheel pinion 6, which gears into and drives the cloth-beam wheel 7.

This arrangement of wheels has been so designed that the number of teeth on change wheel 3 gives the number of picks per $\frac{1}{4}$ in. in the cloth.

Shedding.

"Shedding" is an important operation during weaving, as, when faulty, the yarn is strained, the healds damaged, and the cloth will not be perfect. Whatever motion is used it must be so set that the shed is not opened too wide lest the yarn is strained, nor too shallow so as to allow the shuttle to unduly rub the yarn.

There are three distinct sets of appliances termed tappets, dobbies, and jacquards which are limited to the formation of simple, medium, and difficult designs. These are again subdivided into many kinds of each sort, each with its own peculiar advantage to some special make of cloth.

Tappets are generally used for simple fabrics such as plain cloth, twills, drills, etc.; as a rule all fabrics that require up to six or eight healds are woven with tappets. Tappets are of many kinds, positive, negative, woodcroft (section tappet), rotary, oscillating, etc., and are placed under, at the end, or over the loom.

Dobbies are used as a shedding motion when there are more than eight threads to a repeat of the design, and up to twenty or twenty-four threads is the limit as a rule, although an increasing use is being made of larger dobbies up to 40 heald shafts. There is practically no limit to the capacity of a dobby as regards the number of picks to a repeat.

There is a great variety of dobby machines used to-day for both general and special fabrics—these are positive and

negative in action, and are further subdivided into single lifts, double lifts, open shed, centre shed, and many more.

Fig. 60 shows a modern loom with a dobby machine fixed.

Jacquards. These machines are used in cotton weaving when there are more than 24 threads of warp to one repeat of the design. The jacquard was invented by a Frenchman of that name about the year 1800. The chief feature of the machine is that each thread of the design is separately controlled.

There are many different kinds, such as single lift, double lift, single cylinder, double cylinder, cross border, and others, all having their various peculiarities, advantages, and disadvantages where so many kinds of cloth are to be made.

A modern jacquard loom is shown in Fig. 61.

Picking.

The "picking" motion of a loom is a mechanical arrangement which drives the shuttle from one side to the other between the two rows of warp threads. There are two principal methods used, namely, the "overpick" and the "underpick" motions.

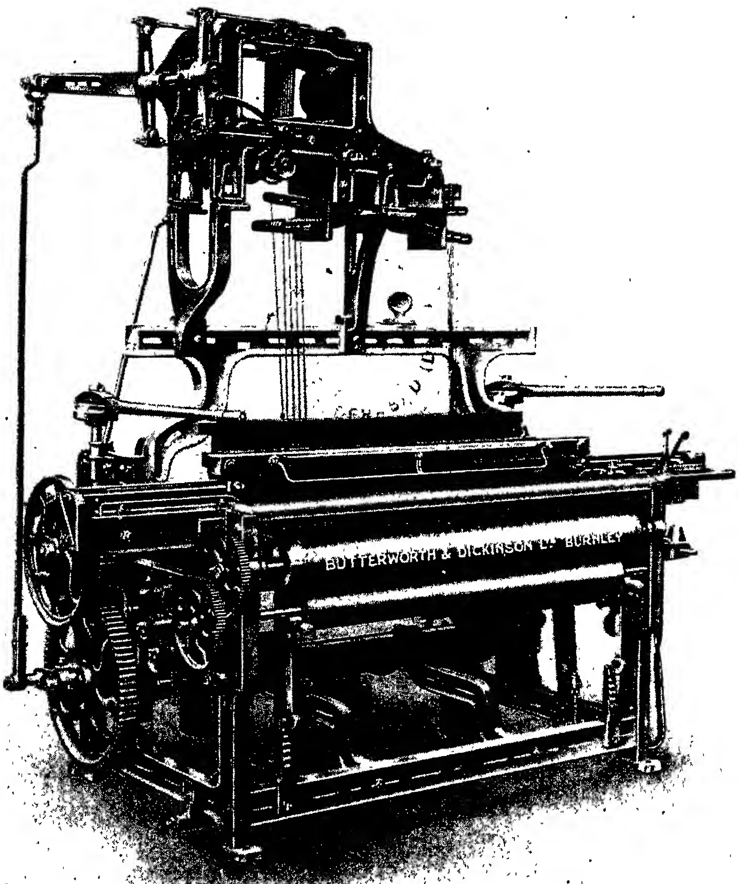
The overpick method is generally found on cotton looms because it is easier to get at for repairs and obtains great speed.

The underpick is cleaner whilst working, and usually fixed on looms used for silk goods and fine expensive fabrics.

The shuttle is usually made from cornel or persimmon wood. It is about 13 in. in length with iron tips at each end. Inside the shuttle is an iron peg on which the cop is corkscrewed and the thread is drawn by the weaver by suction, through the eye of the shuttle.

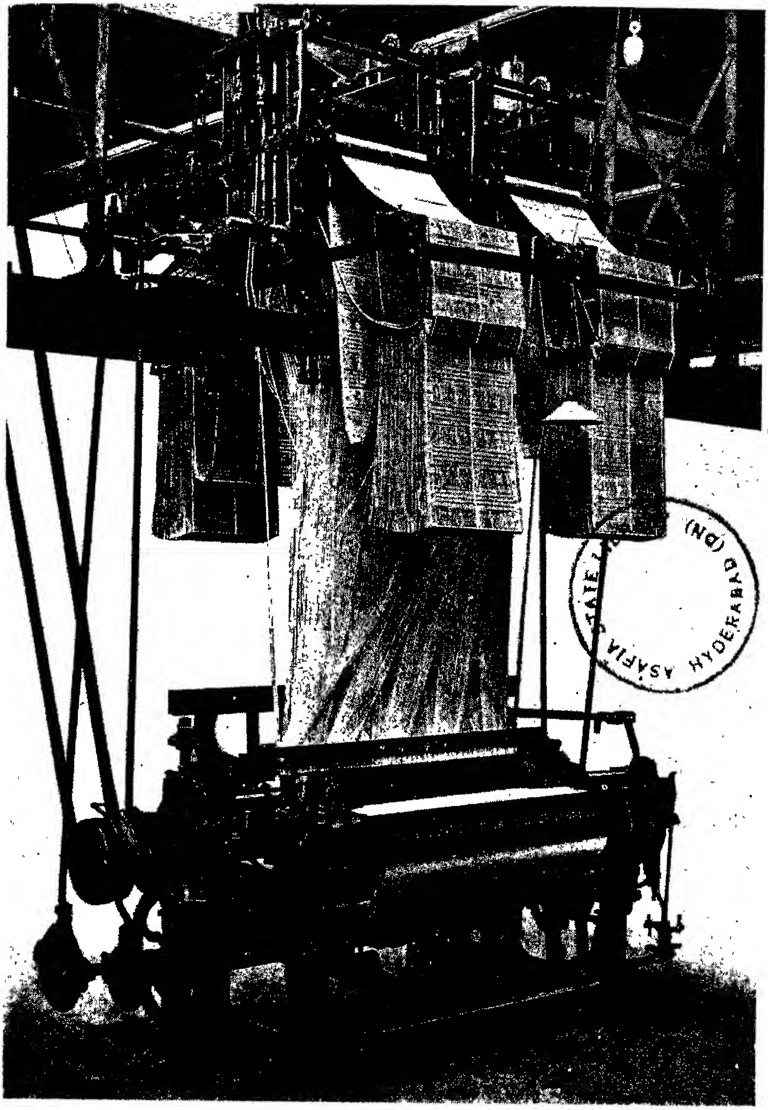
Beating Up.

The beating up is invariably formed in one way in all looms; that is, to carry the reed forward, with the line



By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

FIG. 60. LOOM WITH DOBBY



By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

Fig. 61. Loom with Jacquard

of weft in front of it, up to the edge of the cloth which is being woven. The reed then recedes for some 5 in. for another pick of weft, which is beaten up, and so the weaving proceeds. The loom has also other minor appliances. For instance, one stops the loom when the weft-thread breaks, and another stops it when the supply of weft runs out of the shuttle. A third enables different kinds of weft, automatically inserted in the cloth by means of shuttles (each of which contains a different kind of weft), to be thrown across the loom in any required order.

The Weaving Shed.

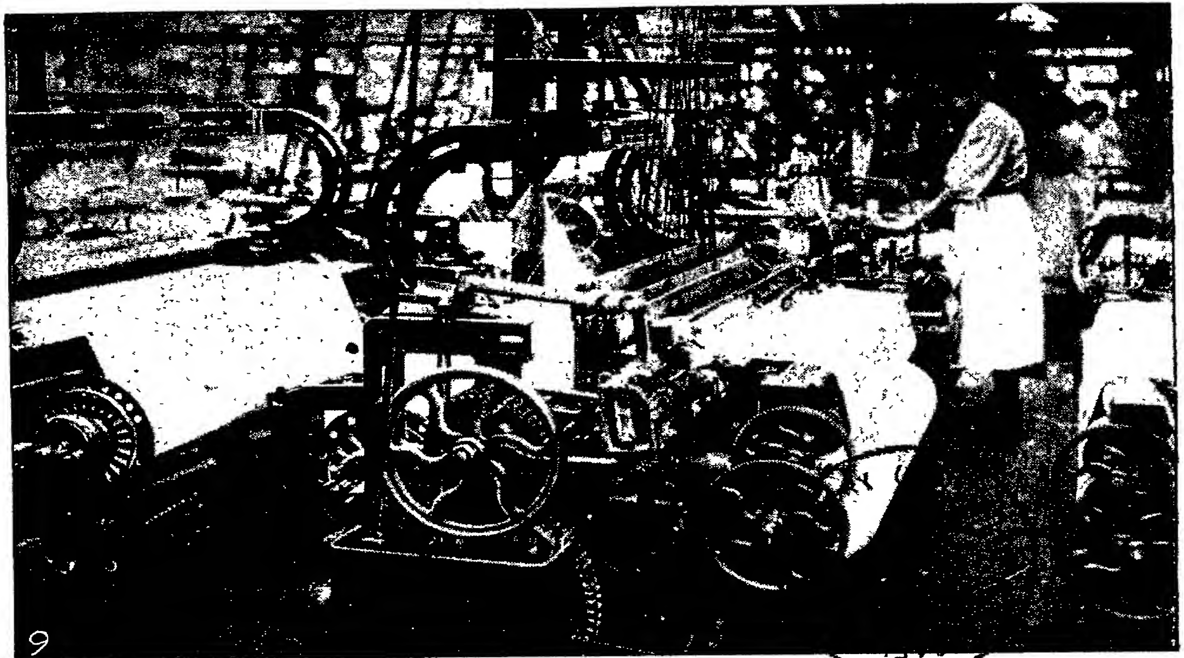
The weaving shed (Figs. 62 and 63) is a most interesting sight, often containing 1,000 looms. The rattle of the machinery is almost indescribable to a visitor, yet to the busy operative it is hardly realized. The shuttle in each loom often passes across the sley 200 times a minute, and a single loom will often weave 200 yd. of cloth in one week. This, of course, varies considerably according to the kind of cloth which is being made. The art of weaving is one which requires considerable skill, the wages earned varying from 20s. to 36s. (for four looms) per week, according to the number of looms which the operative controls, and the class of goods which are being produced. The number of looms operated by one weaver varies from two to six, the average being three to four. The shed and the preparing departments are directed by a manager, who is a thoroughly experienced man with great technical knowledge, and an economical administrator who has to keep strict eyes on the details of expenditure. The weavers are controlled by an overlooker, who is responsible for the work which is turned out by a section of the looms, varying from 60 to 100, according to the class of cloth which is being made. The overlooker, or tackler, sees to loom repairs, to the looms being supplied with warps, correctly gaited, etc., and he has an interest in doing all he can to keep up the production and therefore also the earnings of the weavers.

By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

FIG. 62. MODERN WEAVING SHED—ELECTRIC DRIVE

As will be shown later, the plain and fancy cloths made in such infinite varieties are distributed throughout the world, our two greatest markets being India and China. The spread of the cotton trade throughout the world is most remarkable. For a long time Lancashire was practically the sole producer of cotton cloth, but now the manufacturing system is rapidly becoming adopted by all civilized countries. The competition, too, is extremely keen, and the utmost vigilance is required if the manufacturer is to secure an adequate profit upon the capital invested.

The actual fabrics themselves are divided into five classes: plain, twill, figured, gauze, and double cloths. The ordinary calico is an example of *plain* cloth. *Twills* are those where regularly defined lines run obliquely across the piece. *Figuring* is applied to cloth with more or less elaborate designs, from the common spot to a large floral effect. *Gauze* fabrics are cloths where the warp threads are made to cross each other instead of running straight. A common form of *double cloth* is the woven bag, or pillow-case. Another class may be referred to, though it is really one of the foregoing. It is that of pile cloths, of which velvet is the common form. But in addition to all this, these various classes are subdivided into almost innumerable varieties of each class. Take, for instance, that of plain cloth. Amongst the varieties are shirtings, printers, jaconettes, long cloths, dhooties, madapollams, royal ribbs, poplins, etc.; all these being of a perfectly plain weave but differing in texture and appearance, and adapted for the peculiar requirements of people all over the world. India and China are the large markets for shirtings, but the Chinaman, as a rule, requires a better article than that which will find a purchaser in the Indian market. Dhooties are goods confined solely to the Indian trade. A plain dhooty is a plain calico with coloured edges varying from $\frac{1}{8}$ in. to 3 in. in width, and at regular distances of from 2 to 5 yd. coloured bars of weft, of a



By courtesy of "The Illustrated London News"

Fig. 63. Weaving Plain Cloth

more or less elaborate character, pass across the piece. These dhooties form an important article of clothing in India, the coloured portion being considered a type of ornament. Borders are sometimes also worked up into more or less elaborate figures, and they then pass from the plain section to the figured class, necessitating the use of other appliances to the loom, such as the dobby and the jacquard.

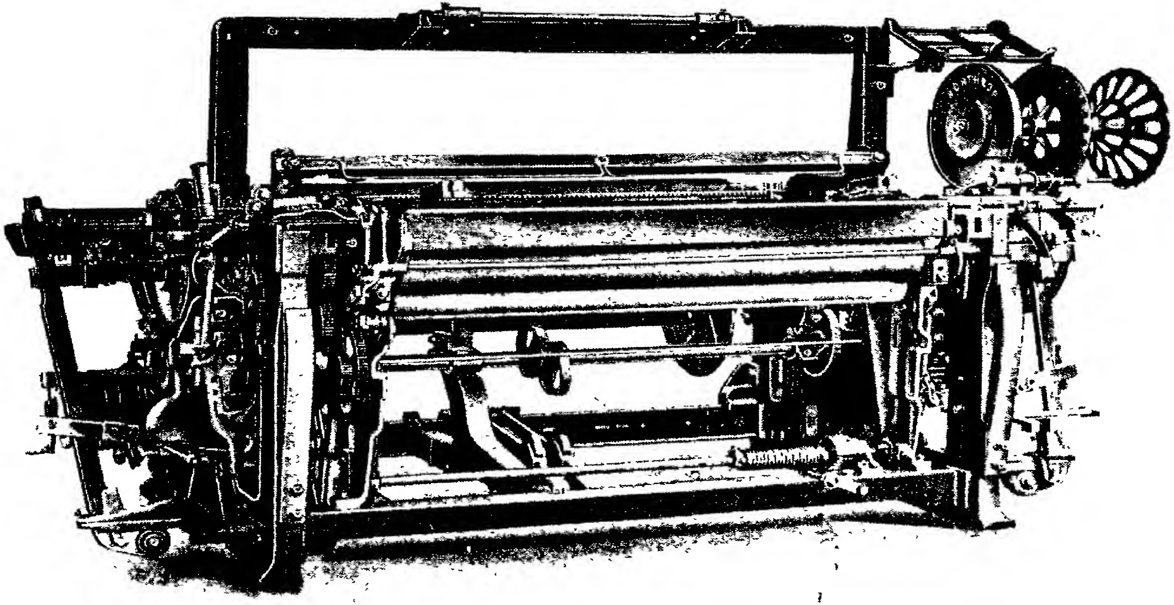
The texture of different classes of dhooties also varies to a very great extent. In some, the yarn is of a very coarse kind and is heavily weighted with size; in others, the yarn is of the finest character, the difference between the two cloths, although for the same market, being very remarkable. Probably the requirements of the various classes, from the very poor to the better circumstanced, is the reason accounting for this. In some cases, the coloured borders, in addition to being elaborate in the way of figuring, are formed of coloured silk threads instead of cotton, thus increasing the value of the piece to a great extent. As nations become more civilized the requirements change from that of a common character to one embodying more or less elaborate detail and better finished articles, and to China and Japan there are now shipped large quantities of the very best class of figured goods. In the near Eastern markets quite different classes of fabrics find sale. We find crimps and crepons in large demand. These are goods which have a crimped or creased appearance on the surface. For the home trade the best qualities of plain goods, as well as the more fancy fabrics, are in demand, and during recent years the production and sale of flannelettes has greatly increased. These various classes of fabrics are in some instances almost confined in their manufacture to certain districts, being in a sense their specialities; but as the spread of education and competition goes on the distribution is more widely spread, manufacturers being gradually forced into producing other classes of articles than those to which they have been accustomed.

Blackburn is probably the largest centre for the making of shirtings, enormous quantities of these goods being turned out daily. A large section of the dhooty trade is also located in the same town, though one or two of the smaller places, such as Darwen and Great Harwood, seem principally adapted for this particular kind of fabric. In the Rossendale Valley the principal manufacture is of coarse goods which are very heavily sized. In Preston and the immediate neighbourhood the goods manufactured are generally of a most elaborate kind, though in the town itself there is probably the first firm of shirting makers in the world. In Bolton district the classes of goods made are chiefly fine cambrics, a great many quiltings, coloured counterpanes, etc.

In the making of velvets a large proportion of the weft threads are allowed to form to some extent loosely upon the surface of the cloth. Under these weft threads a fine knife is run, severing them, and causing the ends to stand upright, which gives the peculiar surface which is associated with velvet cloth. A large use is now being made of cotton to imitate woollen products. One of these is commonly known as flannelette. This is an ordinary cotton fabric made from coarse yarns. After being woven it is passed through a machine which combs up, or teases, the fibre on the surface, giving it the peculiarly fluffy or woolly appearance which is so well known. The heavy pile cloths include corduroy, moleskins, cords, bull-hides, etc.

Automatic Looms.

The intense competition in trade has had the effect of stimulating invention, of patenting appliances for making peculiar classes of goods, and for increasing the production of machinery. One of the most important of the latter kind is the Northrop loom (Fig. 64), an English invention, bought by an American firm, which is largely in use in the United States and has been introduced into Lancashire. Seeing that the automatic principle will



By courtesy of *The British Northrop Loom Co., Ltd.*

FIG. 64. THE NORTHROP AUTOMATIC LOOM

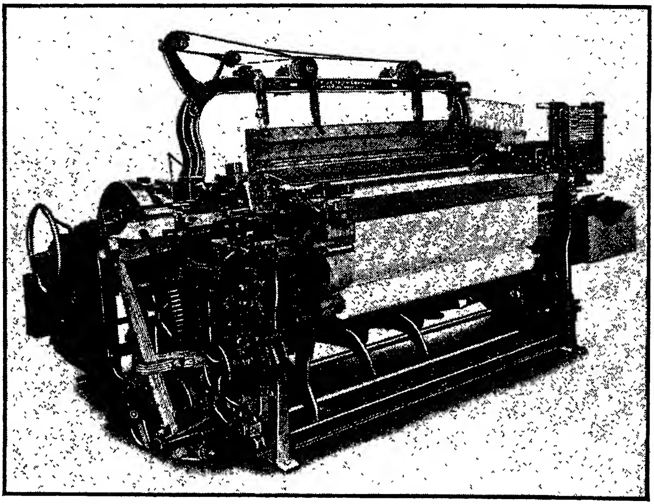
more and more come into use in the future, it will be of value and interest to look into a Rhode Island mill and see the loom at work. There are marked differences in the systems and organizations of English and American mills. A visit was made to the cotton spinning and weaving districts of America by a body of English manufacturers in 1902; they found the Americans were making greater headway than we in England in the economy of production. They found also that there had, within the past quarter of a century, been phenomenal developments in manufacturing in the Southern States, and that there was now a marked growth of their competitive power. In some of the sheds in the Southern States it was found that quite young children were largely engaged, which meant, of course, a large reduction in the wages bill as compared with the North. The goods upon which this labour was chiefly employed were sheetings, jeans, and drills for the distributing centres in China, and it was obvious that the odds operated as heavily against the New England mills as they did against those of England. The American Trade Unions, however, are growing in strength, and the tendency is yearly in the direction of equitable wages adjustment. It was found by the Lancashire commission that the American spinning mills did not get a great advantage over us in the cost of carriage for the raw material. As a matter of fact, Mr. T. M. Young, who accompanied the English deputation, and who wrote the results in a series of articles reproduced under the title, *The American Cotton Industry*, found that the cost of bringing raw cotton to the mills of New England was practically the same as that of conveying it to the Lancashire spinner. In South America some advantage is gained, but it is inconsiderable. The great difference between British and American manufacturing systems is the extensive use in the States of the automatic loom, affecting a marked reduction in the cost of production, yet materially advancing the wages of the weaver. These looms were adopted by Germany,

France, Belgium, and Austria before they were introduced into Lancashire.

It was at a mill close to Fall River, and within the State of Rhode Island, that Mr. Young found 2,000 Northrop looms and 743 other looms, all 32 in. wide or more, making twills and sateens largely from 28's to 36's weft, spun from "strict good middling" cotton of 1 in. to $1\frac{1}{8}$ in. staple. These looms were fed by 17,300 mule spindles and 60,000 ring spindles, and the mill was driven by a steam engine of 2,000 indicated horse-power, the annual consumption of coal being about 8,000 tons, and the cost of coal then being about 13s. 6d. per ton. Seeing that this automatic loom is coming into great use, a description of it will be valuable. Mr. Young says—

The essential difference between it and the common or any other automatic loom is that when the weft breaks or is exhausted, the shuttle is automatically recharged with weft, and threaded without being itself removed from the sley. There is a cylindrical battery or magazine, like a magazine of a revolver, over the shuttle box at the side of the loom, and this magazine can be filled with "cartridges"—either bobbins of ring weft or cops of mule weft. Ring weft for the Northrop loom is spun on specially made bobbins, which are simply laid into the magazines; cops have to be skewered upon a steel spindle, with a wooden head similar to that of the ring bobbin. When the weft-changing mechanism is brought into play by the action of the weft-fork, a bobbin, or a cop on its skewer, is forced from the magazine into the shuttle, which is always then at the end of the sley immediately beneath the magazine; the spent bobbin, or skewered cop, is forced out through the shuttle and the bottom of the sley, and, with the first impulse of the picking-stick, the shuttle threads itself and the weaving continues without interruption. All that the weaver has to do, then, in regard to the weft, is to keep the magazine charged with weft, and as there is always a contrivance in these looms which stops them when a warp thread breaks, the weaver has no need to watch the warps; when he sees the loom standing, he goes and finds the broken end and ties it up and starts the loom again—that is all. The weft magazine may contain as many as thirty charges, enough to keep the loom running for a couple of hours. The Northrop loom (Fig. 64) is the invention of an Englishman, James Northrop, formerly of Keighley; but the Draper Company, of Hopedale, Massachusetts, who bought the patents, have spent very large sums of money in perfecting the machine and adapting it to the varying exigencies of industrial use.

Fig. 64 illustrates the loom for plain cloth weaving with a single shuttle, but it can be built to two shuttles for weft mixing or two- and four-box motions for check fabrics. It is provided with automatic let-off motion (Roper type), automatic mechanical warp stop motion, and a strong ratchet take-up motion with crack preventer,



By courtesy of *The British Northrop Loom Co., Ltd.*

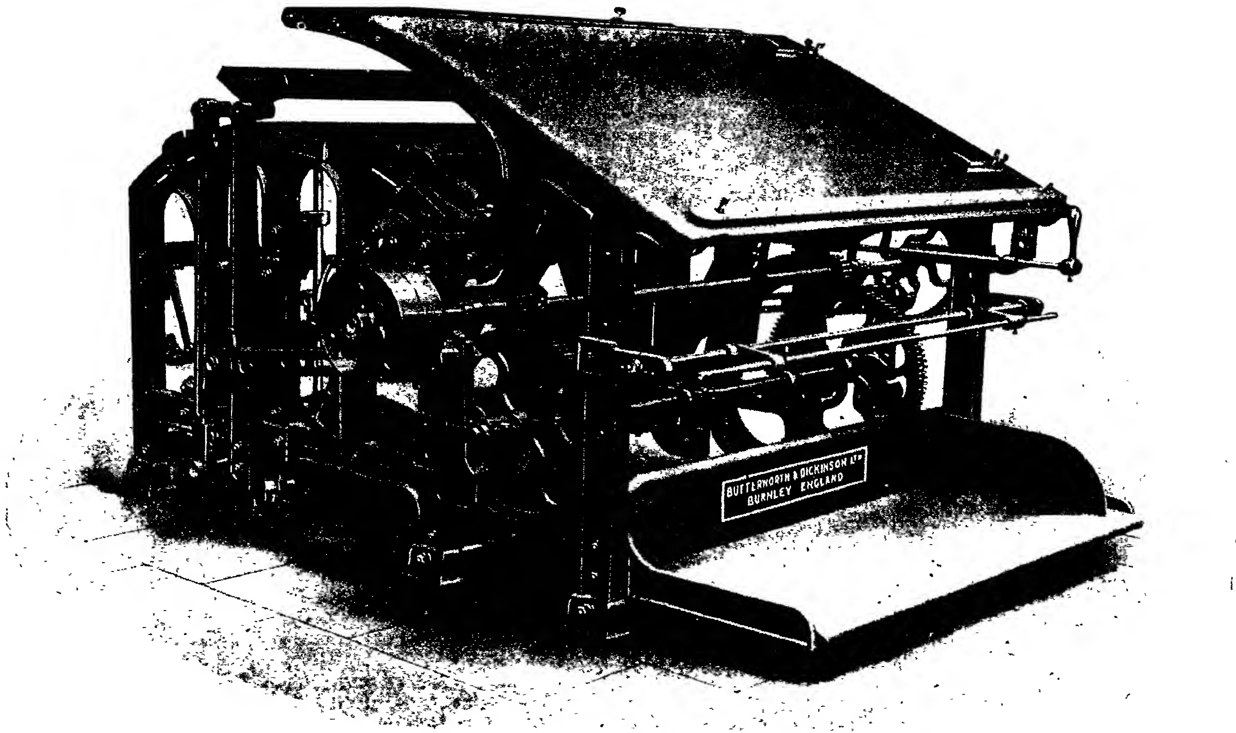
FIG. 65. THE STAFFORD LOOM

also with a spring cloth wind-up motion. The battery holds 24 cops or bobbins for automatically replenishing the weft on detection by a mechanical feeler motion, which reduces the waste in weft to 1 per cent or less.

The speeds recommended are—

28 inch loom,			180 picks per minute			
40	,,	,,	175	,,	,,	,,
48	,,	,,	160	,,	,,	,,
60	,,	,,	140	,,	,,	,,

Though its price is about four times that of our ordinary loom, the adoption of the Northrop loom in this country is steadily proceeding, while there are now upwards of half a million Northrop looms in use throughout the world.



By courtesy of *Messrs. Butterworth & Dickinson, Ltd.*

FIG. 66. CLOTH FOLDING MACHINE

Another type of automatic loom now becoming popular is known as the Stafford loom, Fig. 65. This is a shuttle changer, that is, when the weft has run off the pirn the empty shuttle is replaced by a full one. This loom also was invented by an Englishman and taken up by an American company. There is also the Japanese automatic loom known as the Toyoda, which is largely used in Japan and is a shuttle changer very similar to the Stafford loom.

Warehouse.

From the weaving shed the weaver takes her "cuts" or pieces of cloth to the warehouse, where they are received by the cut-booker, and her wages are made up from the list prices. The cloth is put on the folding machine (Fig. 66) which plaits it into yard folds. The cuts then go (marked with the loom number of the weaver) to the cut-lookers, who stand at their benches and rapidly examine the cloth to discover any imperfections. For cloth faults due to the weaver, such as "floats" caused by failure to interweave at some point, the weaver is "bated" or fined according to the seriousness of the fault. Cracks in the cloth, uneven cloth, cockly cloth, bare cloth, mashes, broken picks, etc., are all noted, as well as any short lengths, wrong widths, wrong weights, incorrect headings; all come within the observing and classifying duties of the cloth-looker. The cloth headings consist of lines or bars of coloured weft at each end of the cloth or in other places. They are to distinguish the piece and to indicate where the pieces are to be separated. Some of these headings are very deep and attractive, with lines of gold thread and coloured weft.

In the cloth warehouse the cloth is made up into bundles. Some are sent directly to the shipper, others go to the Manchester warehouses, where they are again examined, whilst others again go direct to the bleachers.

CHAPTER V

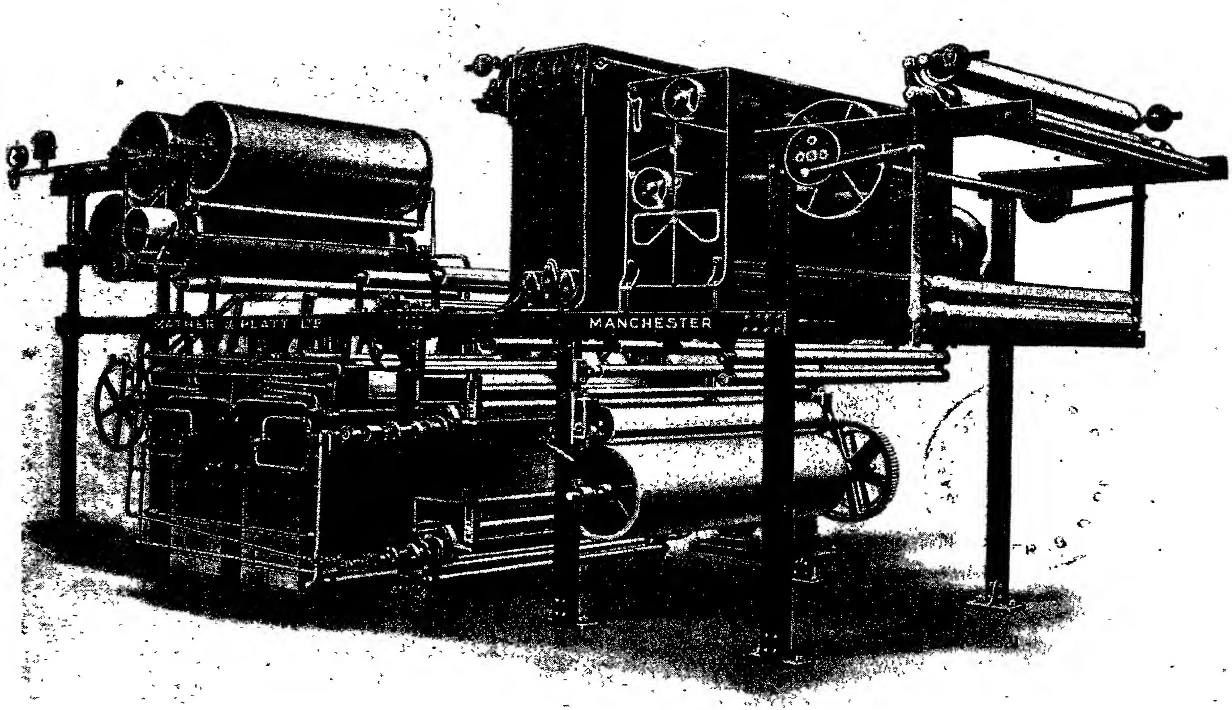
BLEACHING, PRINTING, AND DYEING

THE printing and dyeing of cotton fabrics is something more than a mere mechanical operation. The development of this branch of industry is due to the skill of the cleverest chemists, foremost amongst these being John Mercer, the inventor of the mercerizing process by which cotton cloth is made to resemble silk, and the late Frederick Steiner, a famous French chemist, who introduced a turkey-red dye, famous all over the world.

The arts of bleaching and dyeing were known to the ancients, especially the Egyptians. The early method of bleaching was very tedious, and consisted of steeping the cloth in alkaline leys for several days, washing and spreading upon grass for some weeks. In 1785 perhaps the first real improvement was made by Berthollet, a French chemist, who found that chlorine possessed the property of destroying vegetable colours. A few years later bleaching-powder was invented by Tennant, of Glasgow, and instead of taking weeks to whiten cloth it could be done in two or three days.

Bleaching.

Before it can be dyed or printed upon all cotton fabric must be bleached to rid it of all impurities, or everything present in the fibre except cellulose—or, in other words, a small quantity of margaric acid, pectic acid, albuminous matter, and colouring substance. In woven goods the artificial impurities may amount to 20 or 30 per cent. They consist of grease, starch, and other ingredients used in sizing, besides oil from the machinery. The removal of these impurities in order that nothing but pure white vegetable fibre may remain is the result sought with the highest grade of bleaching

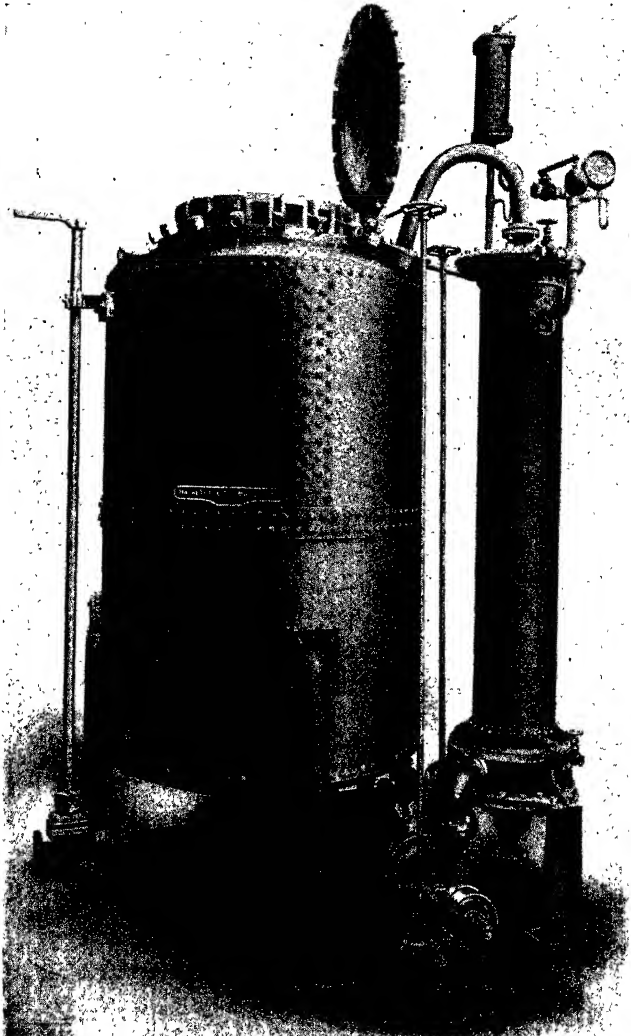


By courtesy of Messrs. Mather & Platt, Ltd.

FIG. 67. COMBINED PLATE AND GAS SINGEING MACHINE

—technically known as the "madder bleach," because it was first applied to goods to be printed with madder, a substance much used in dyeing red. It is also used for cloths which are to receive light and fine colours.

Previous to the bleaching operation proper the pieces are singed, in order that the fine, loose down may be burned off the surface of the cloth, as this down interferes with the production of a fine impression in the printing process. This operation is performed by rapidly passing cloth in the open width over red-hot copper plates (Fig. 67) or between rows of Bunsen burners. While the cloth is drawn rapidly over one or more of these hot plates by means of rollers, a frame with iron bars depresses it tightly upon the hot plates. After passing over the singeing plates or between the gas burners, the cloth is immediately passed through a water trough, or through a pair of wet draw bowls in order that any sparks may at once be extinguished. The pieces are drawn direct from the singeing house, guided by means of glazed earthenware rings, through the washing machine, and plaited down "in pile" on a stillage in the bleach house, where they are allowed to lie a few hours to soften. The second process in bleaching consists in boiling the cloth in milk of lime, and is a very important one. As already stated, the cotton fibre is made up of cellulose and a small quantity of other substances. The object of the lime boil, therefore, is to break up the combination of the wax and cellulose. The selection of lime is also a very important matter, as if the lime be old it will have absorbed carbonic acid from the atmosphere, and this will render it unfit for bleaching purposes. Having been boiled in lime for about twelve hours, the cloth is passed on into the kier (Fig. 68). The cloth must be packed in the kier very systematically, this being done by boys who go into the kiers when they are being filled, and, with their hands and wooden clogs on their feet, carefully press down the cloth in such a way that it will not get tangled in the boiling process. After the goods have been properly



By courtesy of *Messrs. Mather & Platt, Ltd.*

FIG. 68. VERTICAL KIER

boiled the waste liquor is run off from the bottom of the kier and the cloth is drawn by the draw bowls of the washing machine from the kier. At the same time much of the lime and dirt is removed from the cloth during its passage through the washing machine, but as only a portion of the lime can be removed in this way the cloth is next subjected to a treatment with weak hydrochloric or sulphuric acid. The next operation is boiling the cloth with soda ash. After the cloth has received another washing, and passed through a weak solution of chloride of lime and dilute hydrochloric or sulphuric acid, it is ready for being printed upon.

The usual processes employed in bleaching are about fourteen, namely—

1. Stamping cloth numbers and sewing together.

2. Singeing, either by hot plates or gas.

3. Steeping and washing—the cloth is allowed to lie for some hours to soften and decompose size materials.

4. Washing and liming to break up the combination of wax and cellulose. Here the cloth is run through the milk of lime.

5. Kier boiling. The cloth is here boiled in lime. The cloth must be entirely covered with the liquor to prevent tendering which will occur on cloth exposed. This process is termed "bowking."

6. Washing. This must be thoroughly done.

7. Souring. The cloth is now treated with weak acid to convert the lime not removed into a soluble substance which is removed by washing.

8. Washing to remove the remaining lime compound.

9. Boiling with soda ash to remove the fatty acids.

10. Another washing previous to the process of chemicking.

11. Chemicking. The cloth is treated with a weak solution of chloride of lime.

12. Washing.

13. Souring. Cloth treated with dilute acid.

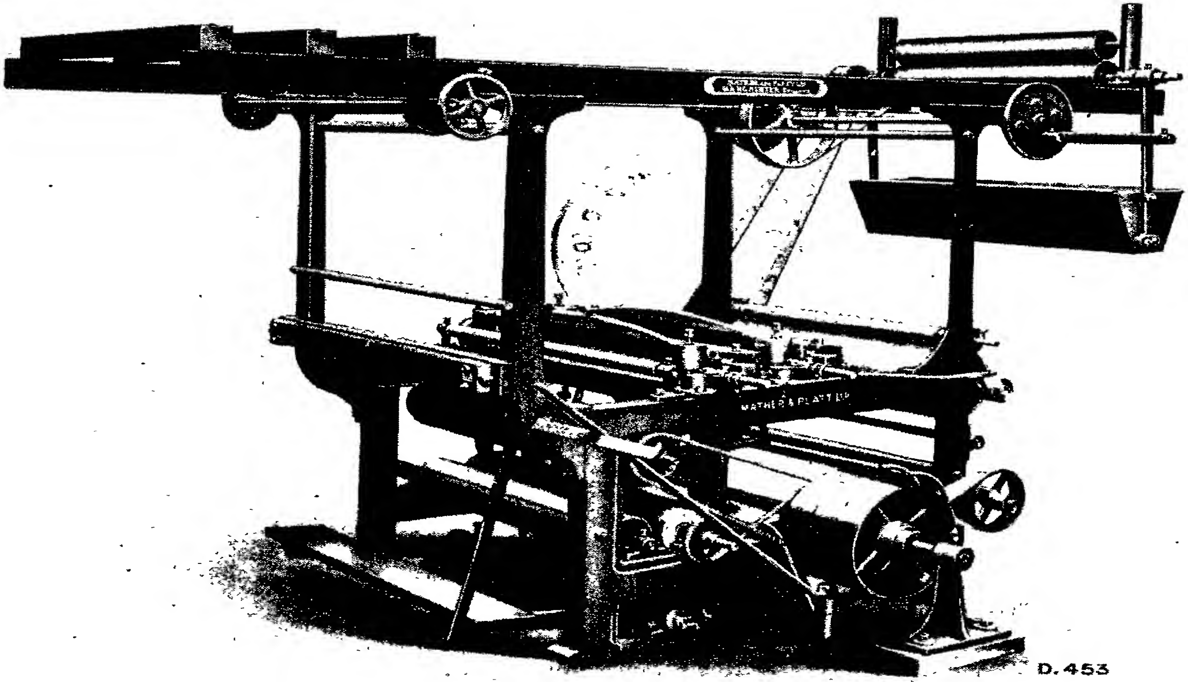
14. Final washing.

In some cases cotton cloth is sheared before singeing in order to remove snarls, motes, ends of threads, etc., from the face or back of the fabric. This shearing or cropping is done by revolving cutters, the cloth being brushed afterwards and then plaited. Fig. 69 shows a modern shearing machine.

Printing.

Block Printing. Until the invention of machinery the operation of printing was performed entirely by hand. The design was applied by means of blocks of some hard, fine-grained wood, such as pear or sycamore. Upon the face of the block the design is carved much in the same manner as a wood engraving. Sometimes the pattern is formed by slips of flattened copper wire inserted along its outlines, which are first traced upon the wood. The copper slips are carefully bent to the required shape and are then forced into the positions they are to occupy by gentle hammering. The upper edges, where the copper stands above the wood, are levelled with a file, in order to form one even surface, and polished. The spaces between these slips are filled up within the boundaries of the design with pieces of thin felt. In hand-block printing the piece to be operated upon is spread out evenly upon the printing table, which is covered with blanketing. Close to the printer stands a tub containing the colour. A wooden drum, like the wood-work of a sieve, is covered with waterproof tissue, over which is stretched a fine woollen cloth, upon which the colour is spread. This drum is placed so as to float on a tubful of paste.

The colour is spread on the drum-head. Then the printer applies the face of the block to the drum-head, lays it carefully upon the cloth and strikes it on the back with a hammer, or presses heavily upon it, so as to force the colour into the cloth. The great drawback to this method of printing is the expenditure of time and labour involved. To print a piece of calico of the ordinary



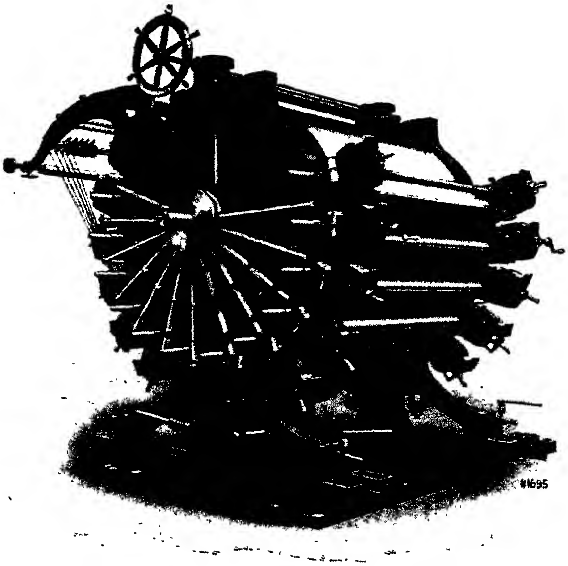
By courtesy of *Messrs. Mather & Platt, Ltd.*

FIG. 69. SHEARING MACHINE

length, 28 yd. by 2 ft. 6 in., with the ordinary size blocks requires about 672 carefully managed applications. If there are four or five colours the number of applications are from 2,600 to 3,300. To a very large extent, therefore, block printing has been superseded by machine printing. Some of the most beautiful designs are still block printed on furnishing fabrics and hangings—a trade that is very high-class and cannot be done by machine work.

Calico Printing by Machines. Calico printing was first introduced into England by a Frenchman about 1676. About 1700 several print-works were established in Surrey to supply printed chintzes to the London shops. Cylinder printing was first introduced by Bell, a Scotsman, at Preston about the year 1785. The machines now in use can print designs embodying as many as twenty different colours, and the largest machines can turn out anything up to 500 yd. of cloth per hour. The design is first engraved on copper rollers. If there are several colours to be printed each colour has to have a separate roller, and it is the duty of the man in charge of the machine to see that all the designs are so fitted that they will form a perfect whole. The machine (Fig. 70) consists of a large iron bowl, or drum, against which are pressed the engraved copper cylinders, the colour being supplied to the cylinders by wooden rollers covered with cloth, or sometimes by cylindrical brushes, called "furnishers." The furnishers revolve in the colour, which is contained in long troughs called "colour boxes." But as the furnishers supply the whole surface of the engraved cylinders with colour, as well as the engraved parts, the surface colour has to be scraped off again, and this is done by means of a steel blade, known as the "colour doctor." The cloth to be printed passes part way round the bowl of the machine and between the engraved rollers and the bowl, when it receives the colour. In order to remove any loose threads or filaments from the roller a "lint doctor" is used, working on the opposite side of the engraved roller to which the colour doctor is applied.

The doctors are made of well-tempered steel, and they have to be exceptionally sharp in order to remove effectually the surplus colour without doing injury to the engraved copper roller. The machine printer has many difficult duties to perform. Besides tuning up the doctor and keeping the pattern rollers in register or fit, he must



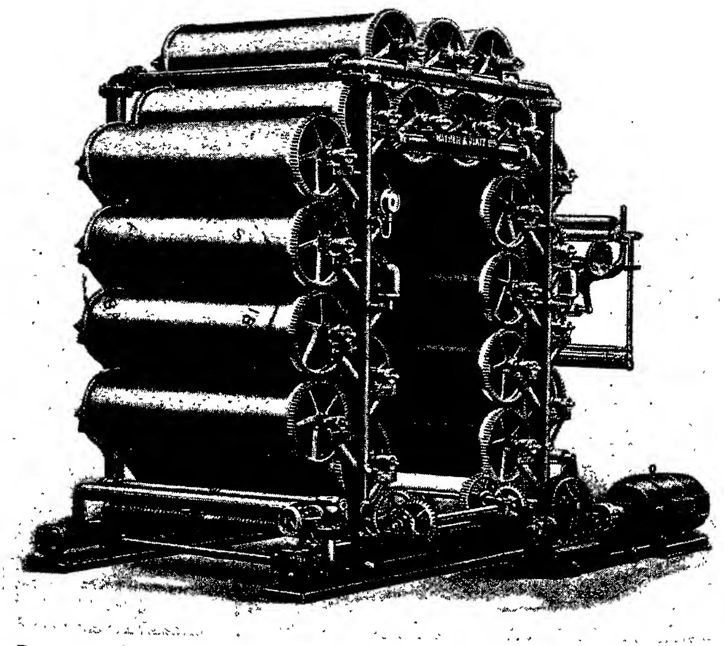
By courtesy of *Messrs. Mather & Platt, Ltd.*

FIG. 70. CALICO PRINTING MACHINE, TWELVE-COLOUR

carefully adjust the amount of pressure, so as to bring out the print and yet not press the colour too far through the cloth.

After the cloth has been printed, the next operation is drying, this being of great importance. The methods of drying vary. In some cases, copper or tinned iron cylinders, heated by steam, are used for the purpose, and in others flat, hollow cast-iron boxes, called steam chests, over which the cloth passes without quite touching. It is necessary to state, however, that after bleaching and before printing, the cloth is prepared with oleine oil.

The most general method of drying is to have the drying machinery in a room above the printing room in order to keep the print room cool. The hot-air system of drying is gradually displacing all others, and for the finest



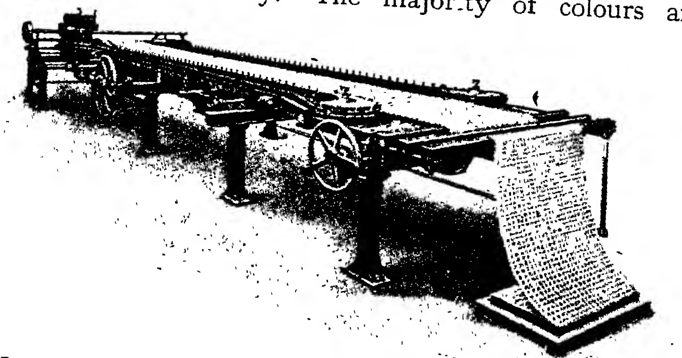
By courtesy of *Messrs. Mather & Platt, Ltd.*

FIG. 71. CYLINDER VERTICAL DRYING MACHINE

and most delicate colours it is the most suitable. In this system the printed cloth is led directly from the machine over a number of steam-heated chests on to the drying chamber. This contains a number of rollers round which the cloth passes and is dried by the constant circulation of hot air. Fig. 71 illustrates one form of drying machine, and Fig. 72 a stenter or stretching machine used to restore width to the cloth which it has lost during the finishing processes.

Colour Preparation.

In the preparation of colour each works has a staff of chemists who are constantly experimenting with a view to securing more brilliant or faster colours. The colour shop contains a number of open copper-jacketed pans of various capacity. They are double cased, the outer cavity being heated by steam or cooled by water as required. Each pan is fitted with geared stirrers. Here the colours are prepared and thickened to the pasty consistency necessary. The majority of colours are



By courtesy of *Sir J. Farmer, Norton & Co., Ltd.*

FIG. 72. STENTER OR STRETCHING MACHINE

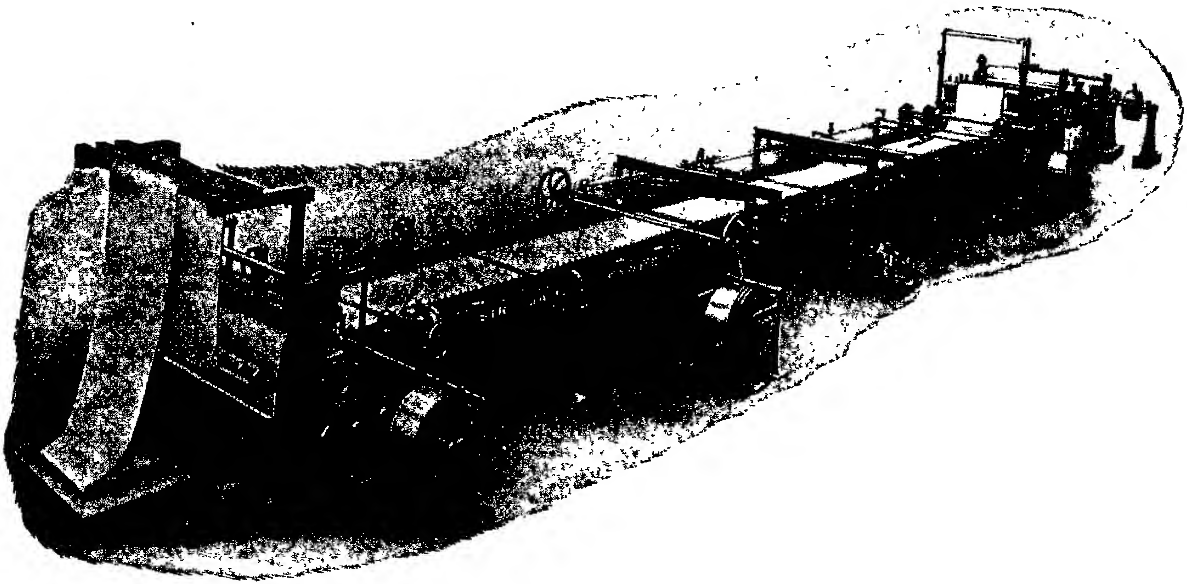
derived from coal-tar. The two mordants, red and black liquor, are very largely used by calico printers in what is called the dyed or madder style, one of the oldest and most important of the various styles of calico printing. In this style the thickened mordants are first printed on, then dried, aged, dunged, and dyed with alizarine, or other acid colouring matter. Before they can be printed, mordants have first to be made into what are technically called "colours." In other words, they have to be made into a kind of paste by means of some thickening matter, as starch, gum, etc. These colours are not necessarily coloured substances, though they do usually contain some kind of colouring. This, however, is only for the purpose of sightening, so that the printer may be able to see his

work on the cloth. This sightening is afterwards washed out of the cloth. Prior to being dyed the cloth must pass through the ageing and dunging, or fixing, processes. The object of the former is to decompose the acetates, so that the acetic acid is driven off, leaving the insoluble bases on the fibre. Steam machines are used for this process. After passing through the machine, the cloth is folded up in loose bundles and left for twenty-four hours. The decomposition of the mordants, which was started by the action of the steam in the ageing machine, goes on slowly whilst the cloth lies in the bundles. As this ageing does not effect a complete precipitation of a suitable mordant on the fibre it must be followed by the fixing process. Then follows the dyeing. After dyeing the cloth is well washed in cold water, and afterwards dried. In the extract style of printing the mordants and colouring matters are mixed together and printed on the cloth in one operation, after which they are steamed. With the extensive use of the many-colour printing machines the extract style has become more prominent, and it gives far more beautiful effects of colouring. Colours for the extract style are printed on cloth previously prepared with oleine oil. By this means faster and brighter shades are produced.

The shades of colour in which the cotton fibre is dyed and printed are almost innumerable, but they are almost all made up of red, yellow, blue, black, and white substances. To obtain the shades the various colours have to be boiled, but it does not follow that all shades are boiled. If a very dark shade is prepared it is a very easy matter to obtain a lighter shade by reducing it. This, in brief, is an outline of the bleaching, printing, and dyeing processes.

Mercerizing.

This is one of the most valuable processes in the finishing of cotton yarn or fabric that has ever been invented, since cotton when mercerized has a silky sheen, is 50 per



By courtesy of *Sir J. Farmer, Norton & Co., Ltd.*

FIG. 73. MERCERIZING MACHINE

cent stronger, and when dyed is far more brilliant than ordinary cotton.

A modern mercerizing range (Fig. 73) consists of a series of machines, namely: a padding mangle for impregnating the cloth with the caustic soda, a stenter, a series of washing becks, and a drying machine.

The cloth, after singeing, is scoured and then passed through the mercerizing range. After treatment in the caustic soda the cloth passes to the stenter without being touched by hand, and here is stretched. While stretched the cloth is thoroughly washed with hot water. From the stenter the cloth passes through washing, souring, and final washing and then dried.

CHAPTER VI

MARKET DISTRIBUTION OF YARN AND CLOTH

WHILST Liverpool is the great market for cotton, a considerable quantity of the raw material comes direct to Manchester, *via* the Ship Canal, the cost of transit being much cheaper for the cotton mills in the Manchester district. The great central emporium for the sale of both yarn and cloth is the Manchester Exchange. Manchester is the Mecca of all connected with the English cotton-manufacturing business. At the end of the eighteenth century the master attended the weekly market at Manchester and sold his pieces in the grey to the merchant, who afterwards dyed and finished them. At times goods were sold outright to the calico printers. Deliveries of prints would be made at the Manchester warehouses from the print-works on Tuesdays, Thursdays, and Saturdays in the busy season of spring and autumn, and the pieces would be sold to the drapers who flocked to the warehouses. At one time the merchant or his representative rode over the country, showing their patterns to the mercers, and the cloths were afterwards forwarded over the roads by the waggons of the carriers. The foreign trade was at the outset—some 240 years ago—founded by British merchants or their agents who travelled, but it was not very long before the representatives or members of foreign firms came and settled themselves in Manchester, and from that day to this they have steadily increased in number. At the present time great commercial houses from almost all the nations of the world are directly represented on the boards of the Manchester Exchange on market-days. The Exchange presents the busiest aspects on Tuesdays and Fridays, the principal market-days, when the floor is crowded with principals and agents—spinners, manufacturers, and

representatives of all firms having direct or indirect connections with the cotton industry. The capital represented is stupendous. Yarn and cloth agents are very numerous. The yarn agent finds the customer for the spinner from whom he receives his commission. Every firm is directly represented on the market and very many have their own Manchester warehouse and offices, some on a very large scale. Some of the most influential cotton-spinning and manufacturing firms are merchants also, and send their travellers out to all the towns and cities of this kingdom and foreign nations. Chapman in his admirable work on the Lancashire cotton industry says—

> The cloth market is far removed in character from the highly developed markets, since fabrics contain all the differences that exist between yarns, and, in addition, all those consequent upon the numerous operations conducted in the weaving shed. Yet we find a rough grading of certain classes of cloth, which the development of machinery is constantly rendering more perfect. Cloths purporting to be the same vary less now that the differences due to human skill have been minimized, and a great uniformity has been introduced in the working of power-looms.
>
> The cloth market is somewhat the same as it was at the end of the eighteenth century. The grey cloth agent, whose function is analogous to that of the yarn agent, is a new feature, and the Manchester warehouseman or shipper takes far fewer risks and stocks less in proportion to the business done than did his predecessor a century ago.

The export business in yarns and cloths is principally in the hands of shippers, but there is a certain number of firms who do their own marketing abroad. There is a decided line of difference between the home merchant and the shipping merchant dealing with foreign orders. Chapman says—

> Selling through independent merchants' houses is to be expected when the commodities dealt in tend to be of sorts that sell themselves, that is, commodities more or less gradable, for which a private market need not be won. Lancashire manufacturers who push their own products over the heads of the merchants are those who produce special classes of goods and depend upon these goods earning and retaining a popularity of their own. When the goods to be sold have to make private markets, or when they are complicated and require to be explained to would-be buyers by competent experts, there is a tendency for manufacturers to

attempt themselves to reach the consumers, or retailers, or the foreign agencies through which such goods can be sold.

Home Trade.

The cotton fabrics manufactured in the mills of Lancashire are principally sold in Manchester to home trade and export merchants or shippers. Probably only about 15 per cent of the cloth produced is sold for home consumption. The home trade buyers take the cloth from the mill in the grey or loom state, finish it, and sell to the retailer in small lots. Many of the large retailers now buy from the manufacturer direct, and there is a very recent development of manufacturers trading to the public through their own shops.

Export or Shipping Trade.

The shipper takes the grey cloth, finishes it, packs in suitable form, and then ships the goods to all parts of the world. He buys and pays for the cloth in a few days, pays all charges for finishing, making up, packing, and shipping, and may have to wait many months before receiving payment. The shipper must have a thorough knowledge of currency, exchange, and finance, and of the habits, needs, and standing of his customers.

There are several systems of trading with foreign markets, such as the indent trade, auction trade, or consigning goods on speculation.

The indent trade is that where a buyer abroad orders a stated quantity of cloth, sending patterns or other particulars from which the cloth has to be made. Full details of packing and shipping are usually forwarded. In these cases, if the goods are to be made to pattern, the shipper takes the risk of their being correct as regards quality and finish. This means that he must keep a staff capable of testing everything connected with the transactions.

The auction trade is peculiar to China, and is purely a gamble. Traders in the villages and towns will send

their orders to a broker in Shanghai for cloth of a known make. The price paid depends upon many influences, and may mean a loss to the shipper. If there is a shortage of these goods then a fair price is received.

When a shipper sends goods abroad on consignment he takes a speculation risk, and may or may not clear a profit. Goods on consignment are generally sent to the shipper's own branch in the overseas market, but frequently the shipper makes arrangements with agents.

Cloth Agent.

The real cloth agent is of value to the industry, but there are very few now in business who carry on their activities on the 1½ per cent commission which is the recognized remuneration. The great bulk of cloth agents to-day are actually merchants, buying on their own account and selling at the best price obtainable, and as a rule are not technically efficient.

CHAPTER VII

TRADE UNIONS

FROM the passing of the Combination Acts in 1799–1800 till their abolition in 1825, trade unions were, in the eyes of the law, illegal organizations, and the early unions of the cotton operatives were founded amid great difficulties. On pages 194–196 there will be found some very interesting excerpts from the rules of what was probably the first of the cotton spinners' unions, established in Manchester in 1795. Preston was the cockpit for many of the early struggles as to wages. Spinners' associations were formed in Oldham and other centres, the Oldham Province being established in 1843, and developing into one of the most powerful trade unions in the country. In 1880 the Bolton Association of self-actor spinners united with the old hand-mule spinners' organization of that town, and, the neighbouring associations of cotton spinners and winders coming into line, there was established the Bolton Province. The Amalgamated Association of Operative Cotton Spinners of Lancashire and adjoining counties was constituted in 1853, but it did not become powerful until after 1870, when a new financial basis was laid down. A union of the weavers of Great Britain and Ireland had been founded in 1840, when the Stockport strike took place, but this proved a very imperfect union. In 1854 the weavers of Blackburn became organized on a sound basis. Other associations were formed in Preston, Darwen, Accrington, Colne, Nelson, and other weaving centres; and in 1884 the various operative weavers' associations became federated in the Northern Counties' Amalgamated Association of Weavers. In 1830 the hands in the card and blowing rooms became organized, and they have grown into a

powerful union. Other departments of the textile industry have their own associations and amalgamations.

The various branches of operatives are now closely linked for mutual aims, and by international conferences are becoming sympathetically associated with the operatives on the Continent.

The present organizations of the operatives are—

The United Textile Factory Workers' Association, comprising eight amalgamations of cotton-trade unions in Lancashire and representing 290,300 members.

The Northern Counties Textile Trades Federation, comprising nine amalgamations of trade unions in Lancashire, representing 291,200 members.

The Amalgamated Association of Operative Cotton Spinners and Twiners.

The Amalgamated Association of Card, Blowing, and Ring Room Operatives.

The Amalgamated Weavers' Association.

The General Union of Associations of Loom Overlookers.

The Amalgamated Association of Beamers, Twisters, and Drawers.

The Amalgamated Textile Warehousemen.

The Lancashire Tape Sizers' Association.

The Amalgamated Society of Dyers, Bleachers, Finishers, and Kindred Trades.

The National Union of Textile Workers, and many other minor organizations.

The operatives' amalgamations appoint representatives to the Legislative Council of the Textile Workers' Association, which deals exclusively with legislative questions affecting the cotton industry. The various societies are also affiliated with the Trades Union Congress, and through it take a prominent part in Parliamentary questions.

There is also a Trades Federation for offensive and defensive purposes, composed, in some towns at any rate, of weavers, overlookers, slashers, cloth-lookers, twisters, and drawers. It is not within the scope of this work to

refer to trade disturbance either by strikes or lock-outs, but the tendency on the part of both masters and employees is in the direction of establishing enduring relationships of peace, based on equitable understandings.

Although the trade unions of England are, to some extent, political organizations, their main purpose is the improvement of the working conditions in the mills, and of wages and hours of labour. Few masters will be found in Lancashire to-day who do not admit frankly that the trade union movement has been of great benefit to the industry as a whole. The textile trade unions have not, as a rule, been aggressive or unreasonable in their dealings with the masters; they have also shown that they can take long views of trade interests. Thus they have contributed liberally to the funds of the British Cotton Growing Association and have, in agreement with the masters' associations, enforced the systematic introduction of short time whenever the industry has been in difficulties owing to shortage of raw material or other causes. In conjunction with the masters, the union officials have worked out standard lists of wages which greatly facilitate the working of the industry, and by means of collective bargaining both sides agree to fixed wages for certain periods. Thus unfair price-cutting between the masters is very much reduced. The unions are very well organized, and only one case has occurred where the men refused to adhere to an agreement arrived at by the officials on their behalf. During the War, the trade unions played a most useful part, especially in the working of the Cotton Control Board, which regulated the rationing of cotton in 1917–18.

The organization of the employers is equally good, and representatives of the employers' Federation are constantly meeting those of the operatives' associations. These meetings, including meetings between local officials as well as those of the Federation, will total up in any one year to well over 300. One of the most important pieces of work accomplished by the Federation and the

unions was the settlement, arrived at in the year 1893, known as the Brooklands Agreement. This was adopted after a stoppage of the Federation mills, which lasted twenty weeks, arising out of a demand by the employers for reduction of wages on account of the state of trade. This broad and statesmanlike agreement was the means of preventing scores of strikes—only one general strike, which lasted seven weeks, has taken place during the last twenty years—but it has now been rescinded.

A word may here be added as regards the Continental trade unions. They make politics their foremost aim and trade improvements secondary. Only on rare occasions will the masters admit collective bargaining; and this may be partly attributed to the fact that the conditions of the industry vary greatly, the industry being less specialized and more scattered than in England, with consequent varying conditions of cost of living, etc.

The following is an interesting historical document showing extracts from the rules and regulations of probably the first cotton spinners' trade union, established in Manchester in 1795.

ARTICLES, RULES, ORDERS, AND REGULATIONS MADE AND TO BE OBSERVED BY AND BETWEEN THE MEMBERS OF THE FRIENDLY ASSOCIATED COTTON SPINNERS WITHIN THE TOWNSHIP OF MANCHESTER IN THE COUNTY OF LANCASTER, AND IN OTHER TOWNSHIPS AND PLACES IN THE NEIGHBOURHOOD THEREOF; ESTABLISHED THE 31ST DAY OF JANUARY, IN THE YEAR OF OUR LORD, 1795, AT THE THREE HORSE-SHOES IN THE MARKET-PLACE, MANCHESTER.

PREAMBLE.

Whereas the Township and Neighbourhood of Manchester contain a great number of Cotton Spinners, many of whom have settlements in distant parts, and when afflicted with sickness, or other misfortunes, cannot obtain relief without bringing a charge and burden on the inhabitants of the respective township, and places wherein they reside; and then only a small allowance, insufficient to support themselves and families; it is therefore agreed amongst them to form a society, in order to raise a fund for the maintenance of such as shall hereafter be in distress, and to defray the funeral expenses of those who may die members of this society.

Excerpts from the Rules

XV.

That no member of the said society shall instruct any person in the Spinning of Cotton (except his own children, and paupers who may receive relief from overseers) until such person shall have paid the sum of one guinea to this society, exclusive of his entrance money and weekly subscription as aforesaid.

XVII.

That if any member or members, after having received his, her, or their wages, shall in a boasting manner (as hath frequently been the case) acquaint different people not being members of this society, what money they have earned in a short time (which has often been very injurious to Cotton Spinners), such person so offending shall forfeit two shillings to the fund, to be paid to the collecting member of the shop where such person shall work, who shall report such misbehaviour to the committee for the time being; and if such offending member shall refuse or neglect to pay such fine after seven days' notice, he shall be excluded all benefit arising from the society.

XVIII.

That if any member shall fall sick, blind, or lame, and thereby become incapable of working, he shall on making known his infirmities, provided they are not such as are brought upon him, or her, by his, her, or their own intemperance, or debauchery, be paid the sum of five shillings and six pence per week during one whole year, in case his infirmities so long continues, or more or less, at the discretion of the arbitrators for the time being, if they find his, her, or their situation may require, but if the member continues sick any longer he shall be paid the sum of three shillings and six pence, so long as he may continue sick, more or less, as the arbitrators for the time being may think proper; but no person shall be entitled to any relief till he shall have been a member of the society for one calendar month; and if any such member happen to be out of work (provided it be not through any default, or misconduct of himself) he shall receive such relief from the society for the time he, she, or they shall be out of employ, as in the direction of the arbitrators for the time being, shall be deemed sufficient; and that in case any member being so relieved, shall be suspected of deceit in his infirmities, the arbitrators for the time being, shall be at liberty to call in some skilful physician to examine the member, who, if he shall refuse to be examined, or if upon such examination, on the report of such physician it shall appear that such member shall have imposed upon the society, he shall be excluded any further benefit therefrom, nor shall he ever again be re-admitted.

XIX.

That in case of the death of any member or members of this society, his or their widow, or widows, or his, her, or their next of kin, shall receive from the fund of this society the sum of five guineas for the funeral expenses of such deceased member or members, more or less, at the discretion of the arbitrators for the time being.

XXV.

That if any person or persons belonging to the said society, shall assault or abuse any master, or other person employed as foreman, or manager, in the business of Cotton-Spinning, or shall do any wilful or voluntary damage to their houses, buildings, or property, on any pretence whatsoever, or shall combine together to raise the price of their wages, contrary to law; or shall make any riot or disturbance against the public peace, or shall disobey any summons, or order of any of his Majesty's Justices of the said county; or be found guilty of any criminal offence whatsoever; such person or persons shall be immediately expelled from this society, and not partake of the advantages hereby intended for the encouragement of sobriety, industry, and peaceable behaviour; and every member of the said society doth hereby agree to observe, and strictly perform all the articles herein contained, so that peace, harmony, love, and friendship may be preserved between them, and their families, and that the Cotton Manufactory may thereby flourish and increase.

CHAPTER VIII

MASTERS' ORGANIZATIONS

THE cotton employers of various districts took early concerted action for the protection of their mutual interests, and each cotton-spinning and manufacturing[1] centre has its masters' association to-day. These associations have become amalgamated and federated into two very powerful bodies. The principal organizations to-day are the Federation of Master Cotton Spinners' Associations with local branches at Ashton, Bolton, Chorley, Darwen, Farnworth, Heywood, Manchester, Oldham, Rawtenstall, Rochdale, Stockport, and Wigan, and the Cotton Spinners' and Manufacturers' Association (formerly known as the N. and N.E. Lancashire Master Cotton Spinners' and Manufacturers' Association), with local branches at Accrington, Blackburn, Bolton, Burnley, Bury, Chorley, Colne, Darwen, Haslingden, Heywood, Nelson, Padiham, Preston, Ramsbottom, Rochdale, and Skipton, one representing the spinning section of the industry, as well as about 80,000 looms, the other the weaving section and about 4,500,000 spindles, situated mostly in N. and N.E. Lancashire.

Some forty years ago most towns possessed a masters' association. Oldham became the most important, on account of the large number of spindles located there; but it was at length felt by the employers that it was no longer possible for disputes, etc., to be dealt with satisfactorily by one association, however large. It was, therefore, decided to form an amalgamation; and in February, 1892, the now famous Federation of Master Cotton Spinners' Associations was established with a membership of seven districts, and embracing firms owning

[1] Whilst in the U.S.A. manufacturing of cotton includes spinning as well as weaving, in England manufacture of cotton is, somewhat illogically, confined to weaving.

17,000,000 spindles. Now it includes thirteen districts and 45,000,000 spindles.

The Federation is the highest tribunal in case of disputes. Any question between employers and workmen is first submitted for decision to the local association to which the mill in question belongs, and, if no agreement can be arrived at, the case is submitted again to a committee of the masters' Federation at Manchester. No strike is allowed to take place without first being discussed locally and again by the central organization. The Federation has its own Workmen's Accident Insurance and Mill Fire Insurance organization, and questions of Parliamentary legislation affecting the cotton trade and other problems, such as the handling of cotton bales, cotton and yarn contracts, etc., are constantly dealt with by special sub-committees.

The Cotton Spinners' and Manufacturers' Association is on similar lines. It is the dominating factor in the settlement of disputes relating to weaving. Whatever the Federation of Master Cotton Spinners' Associations decides as regards wages in the spinning section of the industry is automatically followed by those members of the other masters' association who have spinning as well as weaving mills; whilst any modifications decided upon in the weaving wages by the Cotton Spinners' and Manufacturers' Association are likewise adopted by the weaving mills in the Federation.

In 1904, the year of Sully's successful but short-lived "corner" of the raw cotton supply, the Federation introduced an organized short-time movement; the working hours were reduced from 56 to 40 per week, the idea being that it would be better for the workpeople to have some employment all the year than full-time working for a period and no work at all for a considerable period. Such an organization would, of course, react at once on the price of the raw material; and it has been maintained that the short-time movement introduced by the Federation smashed up the Sully "ring."

The members of the English Federation, however, recognized that England alone was unable to dominate the cotton position, as the United States and Continental countries were using larger quantities of cotton. It was, therefore, decided to call a conference of all the cotton-using countries with a view to discussing the essential problems of common interest to the whole industry. It was not considered fair that one country alone should make the sacrifices involved in short time, for example, and the others benefit equally by such action. After unsuccessfully approaching the British Government to invite representatives to such a conference, the English Federation proceeded to organize it on its own initiative, and the first international conference took place at Zurich in May, 1904, an agreement having already been come to with the Swiss Master Cotton Spinners' and Manufacturers' Association. Nine nationalities were represented at this meeting, and it was recognized by all that there were many questions of common interest to the cotton industry throughout the world. The most important of these was and still is the production of an ample supply of raw material. It was recognized from the outset that it would be folly to take a narrow national point of view in regard to the supply of the raw material, and that no matter where any additional supply came from it would be beneficial to the industry as a whole. It was finally decided to establish an International Federation of Master Cotton Spinners' and Manufacturers' Associations. This was to be a kind of international chamber of commerce specialized for the cotton industry. The English Federation being the most powerful, it was natural that the President of that organization (the late Sir Charles W. Macara, Bart.), who had taken an active part in the formation of the Federation, should occupy the chair of the international organization; but it was decided on England's proposition that every country should have an equal voice in the administration of the Federation's affairs.

Besides the question of the increased supply of the raw material, the International Federation has dealt with the building up of the organization of Masters' Associations in other countries on the pattern of the English Federation; it has endeavoured to bring about closer relations between the cotton planters and the users; it acts as an international intelligence office in all cotton questions; and at its conferences such questions as the handling of cotton, net cotton contracts, mill fire insurance, international boards of arbitration for the settlement of trade disputes, moisture in cotton, etc., have been discussed. The International Federation has also taken a very special interest in the possibilities of the extension of cotton cultivation in India, and the reports of the Secretary's visits to India indicate the manner in which that aim can be achieved.

The International Federation also supplied a long-felt want by collecting and publishing statistics of the half-yearly mill stocks of cotton and the yearly consumption of cotton throughout the world. Prior to the establishment of the International Federation such statistics as existed on these points were largely guesswork; but since 1906 the individual mills have made periodical returns to the Federation offices at Manchester, and the statistics thus compiled are recognized all the world over as reliable.

The annual congresses of the Federation give members an excellent opportunity of exchanging opinions both publicly and privately on other trade matters, and thus friendly relations amongst the nations are also fostered. Congresses have been held in the following cities: Zurich (1904), Manchester (1905), Bremen (1906), Vienna (1907), Paris (1908), Milan (1909), Brussels (1910), Barcelona (1911), Scheveningen (1913), Zurich (1920), Stockholm (1922), Austria (1925), Cairo (1927), Barcelona (1929), Paris (1931), and Prague (1933). Under the auspices of the International Federation, deputations of more than 100 cotton spinners visited the American Cotton Belt in 1907, the Egyptian cotton-fields in 1912, also India,

Brazil, and Colombia, and held conferences with the cotton planters and merchants in these countries. The reigning heads of almost all the countries of Europe have received the committee in audience.

The International Federation has published most interesting reports of all the congresses, and of the visits undertaken by the late Secretary (Mr. A. S. Pearse) to India, Egypt, and the Anglo-Egyptian Sudan, which contain valuable descriptions of the chief cotton-growing areas of the world. The distribution of these reports in English, French, and German throughout the whole industry, both in Europe and elsewhere, has done much to educate both the governments and the public of every country where cotton is grown or manufactured in regard to the world-wide importance and the complicated problems of the cotton trade. The War inevitably interfered with the activities of the Federation, but the publication of statistics was resumed in 1920. Every cotton-spinning country in the world, except the United States, is now affiliated to the Federation. The late Sir Charles W. Macara, Bart., remained President of the Federation until 1914. The President (to-day) 1934 is Mr. Paul Schlumberger (France) and the Secretary Mr. Norman S. Pearse, Manchester.

The following countries are affiliated: Austria, Belgium, China, Czechoslovakia, Denmark, Egypt, England, Esthonia, Finland, France, Germany, Holland, Hungary, India, Italy, Japan, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and Yugoslavia.

The *International Cotton Bulletin* is the official organ of the Federation; it is supplied to all the members of the affiliated associations, and contains original articles on cotton as well as reproductions of the important subjects on cotton matters which have appeared in any part of the world.

Finishing Sections.

The finishing sections also have their own association—The Allied Association of Bleachers, Dyers, Printers, and

Finishers. This Association comprises the following employers' unions—

The Employers' Federation of Bleachers.

The Employers' Federation of Cotton Yarn Bleachers, Dyers, and Sizers.

The Federation of Calico Printers.

The Yorkshire Master Dyers' Committee.

The Scottish Federation of Dyers and Bleachers.

The Manchester Chamber of Commerce.

The records of the Manchester Chamber of Commerce go back to the year 1794. In February, 1794, there was founded a "commercial society" consisting of merchants and manufacturers trading with the Continent of Europe. The India and China trade was then a monopoly in the hands of the East India Company; the East Mediterranean trade was held by the Levant Company, and that of Manchester with the Western Hemisphere was conducted by firms who did not at first join the society. On the establishment of the Chamber of Commerce in 1820 the archives and funds of the older body were transferred to the revived organization.

Practically all the members in 1794 were cotton and other textile traders, and in 1820 at least 90 per cent were directly connected with the textile trades. To-day (1934) there are many other trades represented, but the cotton trade still has 50 per cent representation.

The chamber specializes in looking after the interests of the export trade in cotton yarns and piece goods, and has special committees for the following sections: Yarn—Dominions and Home Trade, Africa, India, China and Far East, Europe and United States, Central and South America, Egypt, Greece and Levant, Grey Cloth and Artificial Silk.

The chamber's "Information Service" keeps all information relating to the export trade, such as foreign customs' tariffs, developments abroad, new regulations, etc.

A "Tariffs Department" deals with all matters concerning foreign tariffs, which is one of the most complicated things in trade.

The "Arbitration Tribunal" is also a very valuable part of the chamber's work, and the decisions given are without fear or favour, and uphold the chamber's reputation for equitable awards.

Probably the finest testing house in the world is the Manchester Chamber of Commerce Testing House, which tests yarns and cloth for any of the numerous faults, damages, or differences that can possibly occur, and gives certificates which represent, not opinions, but scientific facts.

In 1925 the chamber, realizing that all cotton trades were represented by the chamber, and that there was a powerful case for co-operation in the cotton trade, invited all the cotton-trade organizations to set up a committee which would be a channel of communication between the sections and a basis on which they might meet to draw up united plans.

As a result of this invitation the Joint Committee of Cotton Trade Organizations came into being.

The Joint Committee of Cotton Trade Organizations.

This committee is a voluntary association consisting of representatives elected by the following bodies—

Federation of Master Cotton Spinners' Associations.

Cotton Spinners' and Manufacturers' Association.

Bleaching Trade Advisory Board.

Federation of Calico Printers.

Piece Dyers' Association.

Employers' Federation of Cotton Yarn Bleachers, Dyers, and Sizers.

Coloured Goods Finishers.

Master Packers' Association.

Shipping Merchants' Committee (Manchester Chamber of Commerce).

United Textile Factory Workers' Association.

Joint Dyers' Societies.

National Union of Textile Workers.

There are, in addition to the above elected members, a number of co-opted members covering banking and other interests, including the committee of the Cotton Trade Statistical Bureau which acts as an executive for, and provides the secretariat of, the Joint Committee.

The Joint Committee is not concerned with hours and wages, or with technical questions of production, except indirectly, in so far as labour and other costs affect the sale of British cotton goods. The main movements affecting the sale of British cotton goods since the War as compared with the pre-War state of the industry are shown in a statistical summary which has been prepared by the Cotton Trade Statistical Bureau.

Each section of the industry lays evidence before the Committee of Inquiry upon its own problems and difficulties. The Joint Committee, representing the trade as a whole, both employers and employed, endeavours to deal with the position from the point of view of the trade as a single entity.

Never before, it is believed, had all the different branches of the trade discussed their problems as colleagues. This feeling of unity naturally did not emerge at once, and it was only after the Committee had been meeting for some time that the outline of a general policy began to emerge.

The main work of the Joint Committee Executive has been to supervise the principal lines of inquiry recommended in the Report of 1927, namely—

1. Studies of competition in leading markets.

2. Methods of cotton buying and possible economies.

3. Efficiency and the economy of production in the spinning section.

4. Desirable mechanical improvements in manufacturing, and the general adaptability and efficiency of the section.

5. Joint examination by merchants and finishers of

their common problems, with special reference to the possibility of developing export trade.

6. Efficiency and the cost of merchanting.

Technical Education.

The great advancement in technical education has made, and will probably still further increase, the production of cloths of an artistic character. In the technical schools of Lancashire and other counties, in which cotton-spinning and manufacturing are conducted, the textile classes are attended by large numbers of students, some of whom have obtained important managerial positions. There are thousands of students from the operatives' ranks who can bear testimony to the great advantages they have gained through the courses of instruction given in these institutions. Examinations are periodically held, and the prizes, on a very liberal and attractive scale, are given by Local Authorities, County Councils, the City and Guilds of London Institute, the Worshipful Company of Drapers, and other bodies. The instruction given is not merely theoretical. The latest machinery is set up in some of the institutes, and the whole details of both the spinning and manufacturing processes are made manifest.

The results of the great efficiency of the technical education is seen in every mill, even in those older mills where the machinery is very old, so old that only the trained operative can get any work out of it at all.

Technical education is of such importance that it is worth while giving in full the remarks made by W. Munn Rankin, M.Sc., Principal of the Burnley Municipal College at a meeting in November, 1931, when he said[1]—

> The purpose of textile education is to train the personnel of various grades in each sub-section of the industry to understand the theoretical basis of an efficient technique, to keep an alert mind towards problems of daily occurrence and of new knowledge as it comes in from time to time both within and without the industry. Within every section of the long process of conversion

[1] In a Lecture to the Burnley and District Textile Managers' Association.

of raw material to the saleable article at least three distinct grades of personnel are generally recognized: the rank and file, operative foremen, departmental manager, and factory or office managers; and, over all, the controllers who may still be heads of individual firms, or the salaried general managers of combines or groups.

The functions of each class of men concerned as producers or controllers are special to each class as, of course, are the content of knowledge, kind of experience, and dominant factor of personality. Thus the overlooker must know his job in its particular details and also as relative to other operations; his training and frame of mind, as related to his daily work, will differ from those of the sizer, the warehouseman, the clerk, and the weaver. The departmental manager, and in his grade the chief of a firm or combination, must have his particular knowledge, experience, viewpoint and dominant characteristics. Technical education in an efficient system of public education is linked up organically with an efficient system of industry. As education is a prime necessity of a true democracy, so technical education is the necessity of a prosperous industrial community. The lesson of the success of our national industry in times past, and of that more recently of our competitors in Germany, America, and Japan is that industry can only prosper with a sufficiently intelligent and efficiently trained personnel in all ranks. The natural dexterity of the craftsman, and the inherent alertness and business capacity of the controller are to-day not enough: they must be trained, by development within an appropriate atmosphere of ordered instruction and experimentation, and one as varied and wide as is reasonably possible.

The education of the young rank and file in the textile industry has proceeded so long that to-day it is pretty well standardized. The operative enters the evening textile department, at sixteen years of age, after one or two years in a junior institution or continuation school, and starts upon a three years' course of part-time study, requiring attendance for three evenings of two hours weekly for some thirty weeks in the winter months. His studies cover the theory and practice of weaving or spinning, and mathematics, mechanics, machine drawing, and art or chemistry, as may be readily applied to one or other of the main divisions of the textile industry. Such a craft course but serves as a basis of a more advanced course of two further years, in manufacturing and design, inclusive of a special study of ancilliary subjects as economics, engineering, and more chemistry, so that he may obtain the full technological certificate of the City and Guilds of London Institute. The ordinary operative will be content with two or three years of the general foundation course, as an introduction to a narrowed or intensive course of definite craft instruction, as machinist, overlooker, tape sizer, warehouseman, painter, finisher, or other sectional occupation. It will be the student of greater ambition capacity and with interest in an intellectual pursuit who will take the two further years leading up to his final certificate. Such a student may hope to have ultimately the

chance of a position as manager or in an equal grade. But the fact, of course, is that but few of the scores of young workers who yearly obtain the full technological certificate after five years' study have any sort of opportunity, even under favourable conditions of trade, of rising out of the ranks of craftsmen. With the rest the study and discipline of their adolescent leisure must be largely its own reward. The matter does not, however, rest there. These men in the aggregate represent a large section of the operative ranks; they must always exercise, perhaps wholly unconsciously, a considerable influence upon the general attitude of the operatives towards industrial and economic questions as they crop up. It is by such that the standard of general intelligence and industrial efficiency, which is a particular feature of the cotton textile industry, has been long maintained. Under the new conditions this standard of trained intelligence among the rank and file must be more than maintained if the industry is to hold its own.

The training of the next higher grade, that of departmental foremen and managers or factory managers, should be such as to provide a broad, deep, and sound knowledge of the industry as a whole, and more particularly a practical experience of the branch with which they are immediately concerned. This would come in great part by the full five years' part-time certificate course, to which had been added, especially while already a manager, further training in college textile laboratories in the technique of research problems likely to crop up in the course of ordinary work. The manager should have a familiarity in investigation, a freshness of outlook upon old and new knowledge alike, and should be alert enough to find the acquiring of new knowledge an interesting pursuit. These are purely intellectual requirements: others, no less important, are necessary in respect of temperament and general personality. The process of part-time college training cannot assist here, except indirectly in giving a man understanding in the widest sense.

The training of executives of the first and second ranks, such as general managers of large undertakings or as owners, is a matter that plainly calls from the cotton industry the closest concern. It is here that most hard thinking requires to be done. There is nothing amiss with the technical training of the rank and file, so far as it goes, nor with that of the younger men who are already managers, or aspire to become managers, but the same answer cannot be given of the higher textile control, as one can give of the executive of the engineering or chemical industries. Taking a lead from the practice of these more scientific and prosperous national industries, it would seem right to suggest as a basic requirement, a sound secondary school education up to matriculation standard, in general modern subjects, such as physical and chemical sciences, with mathematics and one or two spoken languages. After schooling, a youth should enter a factory in some general capacity, and should also attend the local technical college at least two full day periods, and two or three evening

periods weekly, and there prepare for his full textile certificate. At eighteen, it would seem that the new type of intended executive should proceed to a university and study there in some modern school, not necessarily, nor advisedly, taking only textile technology; indeed, it would be well if he got a fairly competent knowledge of industrial and social economics, both of wider application and as bearing more immediately upon the industry in which he will ultimately have the responsible charge of business and of personnel. He should keep in touch with the factory by spending his vacations there. After the university phase he should return full time to the industry, and there both extend his practical knowledge and build into it the formal training of the university classrooms and laboratories.

The requirements of an executive are a wide, but sound, knowledge of the industry at large, a particular knowledge, but not necessarily dexterity, in all departments of his particular branch, and quickness to appreciate the significance of new knowledge, and chiefly of that issuing from the Research Institute of the industry, a sympathetic understanding of the points of view and difference of personality in others, and such general culture as may give him entrance into any class of intelligent, educated men, particularly among the executives of his own grade in other industries, both at home and abroad. There is a grave need for the raising of the technical and cultural standard, and a broadening of the vision of the average textile executive, if he is to meet on equal footing with his opposite member in the engineering or chemical industry, or in the Continental textile industry. Crude intelligence, the chance possession of a complex of certain odd factors of personality, and the luck of opportunity which made for success under the pre-scientific days of the cotton industry, when competition from trained educated leaders of high breeding and culture elsewhere in the world was unknown, useful though they still are and must continue, are to-day plainly inadequate, if the Lancashire trade is to be stayed in its decay.

In a word, the times need more and better technical education, more comprehensive, for the highest grades of experts and executives.

The Textile Institute.

The Textile Institute was founded in 1910, and in 1925 was granted the Royal Charter of Incorporation; thus it was empowered to elect duly qualified members to Associateships and Fellowships (A.T.I. and F.T.I.).

The Institute also has among its many objects the following very important interests—

To advance the general interests of the textile industry, more particularly in relation to the acquisition and application thereto of scientific knowledge.

To promote the knowledge of the art of producing threads and fabrics of every description.

To constitute an authority for the determination and recognition of technical and trade standards, terms, definitions, and the like, for the textile industry.

To foster the systematic study of problems in their relation to the textile industry.

To promote the perfecting of present methods and the inventing of new or improved methods concerning textile raw materials, and the various stages of their manufacture.

To appoint special commissioners to investigate and report upon problems and processes pertaining to the textile industry.

The Institute only grants the Associateship or Fellowship to those who are of outstanding merit with regard to scientific knowledge and practical experience.

British Cotton Industry Research Association.

In June, 1916, this Association was founded. In May, 1920, premises at Didsbury, Manchester, were purchased and named "Shirley Institute." Special laboratories were built and large extensions added in 1922, 1924, 1927, and 1930.

The work of the Institute is never done; the research workers have always some problem in hand, and it is only by the co-operation of these scientists with the practical men in the trade that results of value can be obtained. Research is being applied to diagnosing the causes of faults in cotton yarn and fabrics, determining the types of cotton in any given fabric, and finding out the cause of lustre differing in finished fabrics. Spinning, doubling, weaving, scouring, bleaching, and mercerizing have all been investigated and subjected to the most exhaustive scientific and mechanical tests; in fact, the researches cover every phase of progress from the cotton plant to the finished fabric.

The Institute has done much good work already, especially connected with the problems facing spinners on the opening and cleaning of cotton. As a result of study on this subject the "Shirley High-Speed Dust Cage" was invented, and the "Shirley Analyser for Raw Cotton and Waste" has just been patented (see Figs. 14 and 15).

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